Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

AUGUST, 1948

TECHNOLOGY DEPARTMENT

TABLE OF CONTENTS, Page 35

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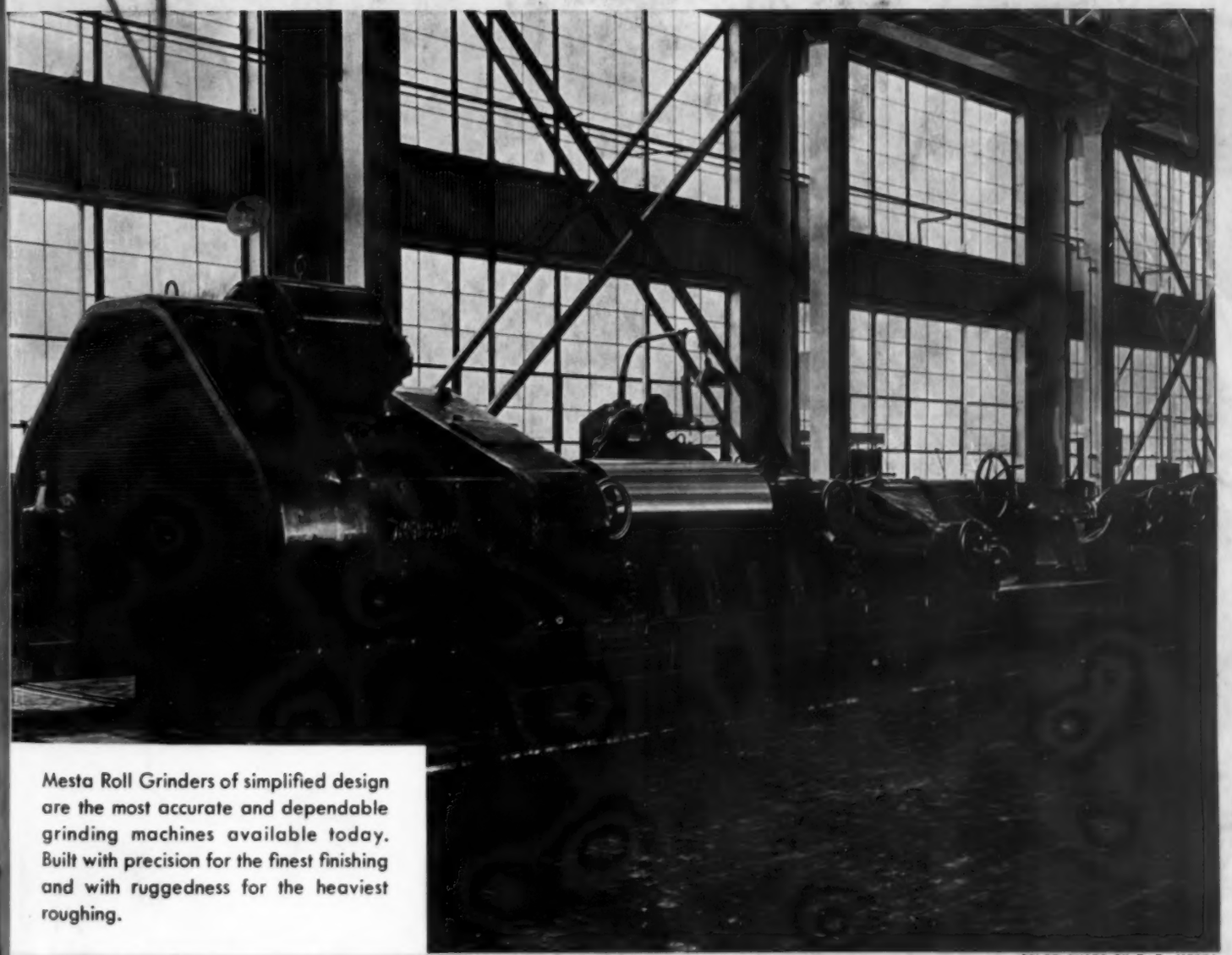
DETROIT

MESTA Heavy Duty ROLL GRINDERS



Mesta Roll Grinders of simplified design are the most accurate and dependable grinding machines available today. Built with precision for the finest finishing and with ruggedness for the heaviest roughing.

COLOR PHOTO BY E. D. MESTA

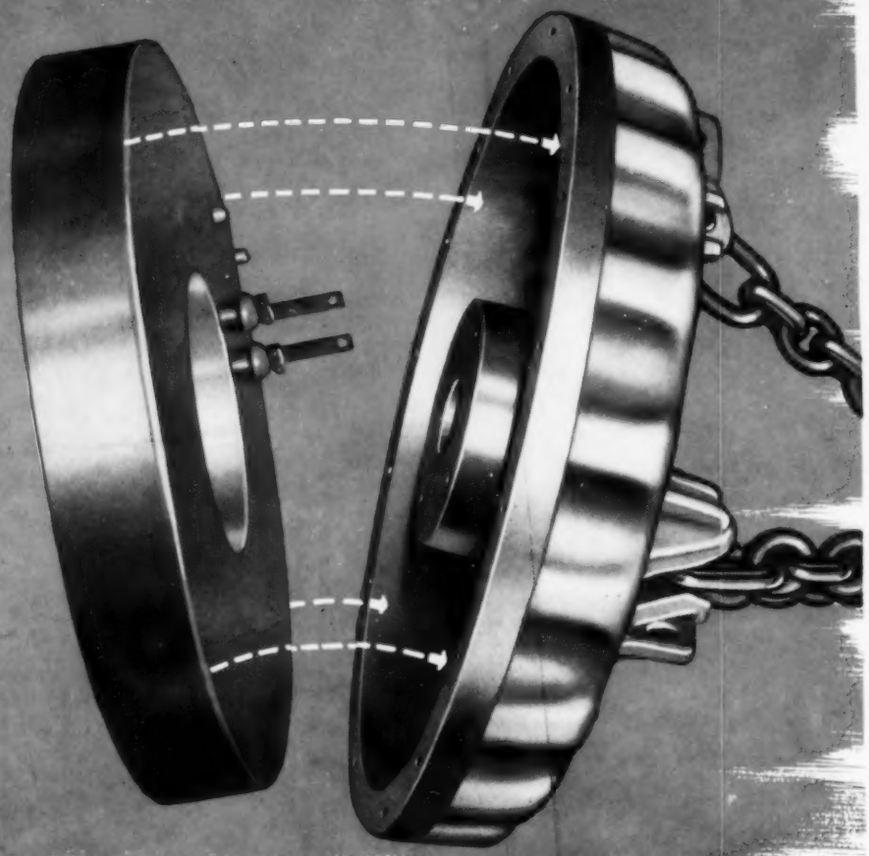
Mesta 60" Heavy Duty Traveling Wheel Head Type Roll Grinder

DESIGNERS AND BUILDERS OF COMPLETE STEEL PLANTS

MESTA MACHINE COMPANY · PITTSBURGH, PA.

Now! New CAPSULE-COIL Magnet Construction

FOR LONGER LIFE AND EASY ON-THE-JOB COIL REPLACEMENT



Now! New anti-wear features prolong chain life

Cutler-Hammer Supermagnets now embody a new welded, steel-sheathed CAPSULE-COIL sealed against moisture. With this new design plus removable pole shoes *YOU CAN REPLACE A COIL* easily, quickly and with a minimum of "time-out." For coil repairs, only the CAPSULE-COIL need be returned to the manufacturer. With a spare CAPSULE-COIL replacement, your Supermagnet goes back to work at once.

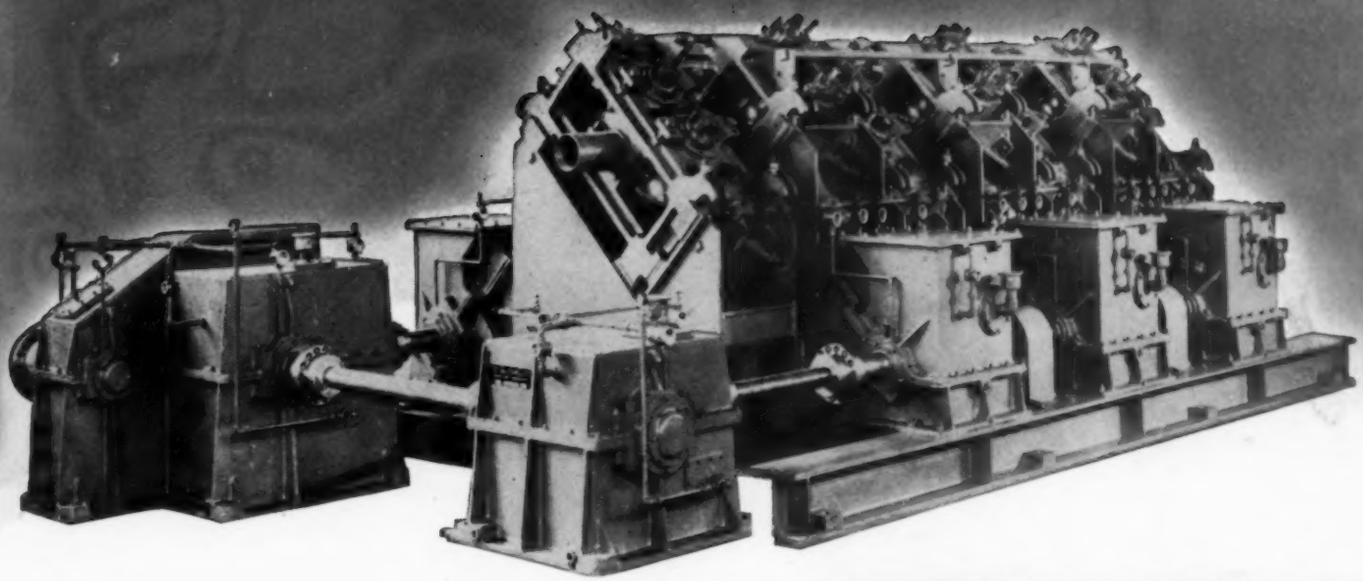
Also NEW, a radically different chain suspension, replacing the conventional top link with a new "non-twist," anti-wear yoke. This, plus redesigned, streamlined body lugs, materially eliminates trouble at the spots where chain usually wears out.

These major Cutler-Hammer advances match other Supermagnet features . . . high permeability steel spool, part of magnetic path . . . strap copper windings insulated by impregnated asbestos ribbon . . . high dielectric, bonded, mica discs between coil layers and CAPSULE case . . . an improved impregnation and insulating process. These superiorities—the result of 50 years of engineering leadership—merit your selection of "Cutler-Hammer" for your next magnet requirement . . . CUTLER-HAMMER, Inc., 1257 St. Paul Ave., Milwaukee 1, Wisconsin.

CUTLER-HAMMER
SUPERMAGNETS
C-H

IRON AND STEEL ENGINEER, published monthly by Association of Iron and Steel Engineers, entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress, March 3, 1879. $7.50 per year in United States, $8.25 Canada, $10.00 foreign countries. Volume 25, No. 8.

AS THE RECORD STANDS



*AETNA-STANDARD has shipped more SIZING MILLS than any other Company

Aetna-Standard's accredited leadership is evidenced by installations made, orders being processed and those being received. With Aetna's knack of ingrained, practical know-how, and the versatility of its forward-looking engineering, you can achieve money-making efficiency with low maintenance cost by relying upon Aetna sizing mills . . . as do other industry leaders. The two types of sizing mills, closed housing and overhung rolls, are built for sizing butt weld, lap weld or seamless tubes from 3/8" to 24" O.D. As specialists, we combine experience, facilities, and knowledge for one purpose — building the most efficient mill equipment for your use. Ask for sizing mill data based upon your specific requirements.

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YOUNGSTOWN, OHIO

ASSOCIATED COMPANIES:

HEAD, WRIGHTSON & COMPANY, LTD., THORNABY-ON-TEES, ENGLAND

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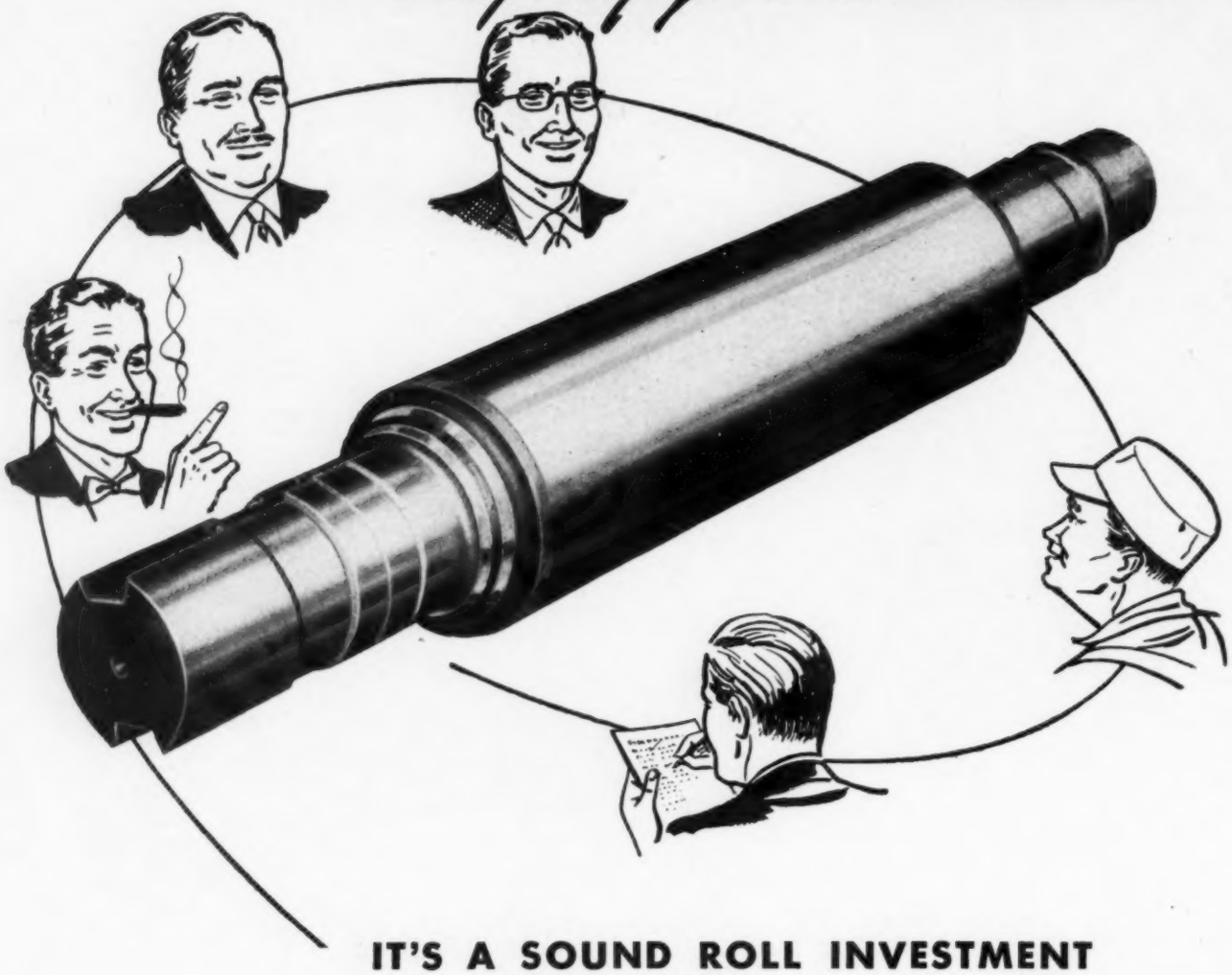
Anyway you look at it!



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From the view point of operations, costs, sales departments and management, National Rolls turn out top quality work at exceptionally low cost per ton formed. The care and precision that go into their manufacture are directly reflected in their dependable performance on the stands.

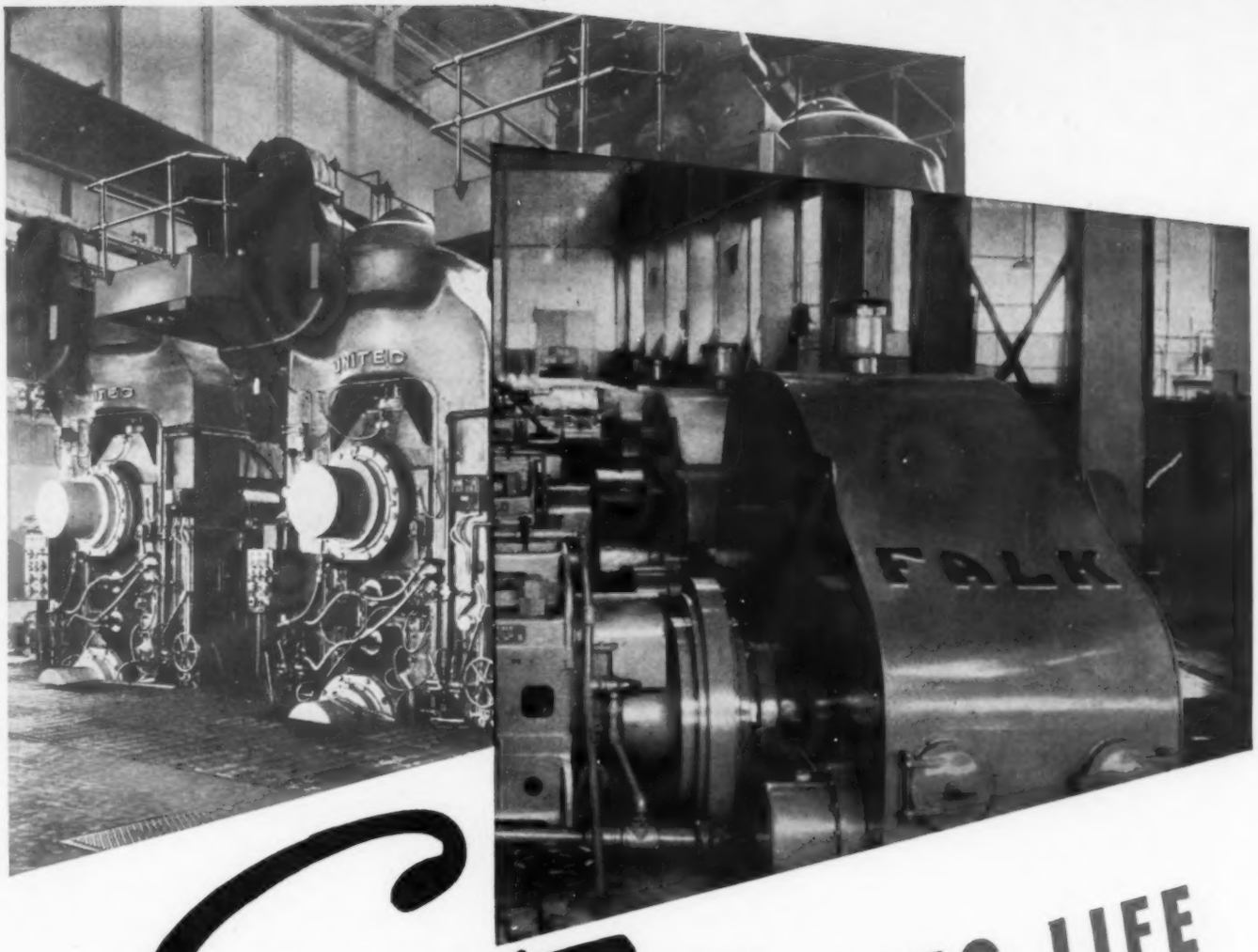
For a long term investment in roll satisfaction you can do no better than to specify National. Just ask any of our customers—they're our best salesmen.

National Rolls

THE NATIONAL ROLL & FOUNDRY CO.

AVONMORE, PENNSYLVANIA

SPECIALISTS IN IRON AND ALLOY IRON ROLLS



Extra LONG LIFE FOR GEARS

PROTECT your reduction gear drives with *Texaco Meropa Lubricants,* and they'll operate more efficiently, require less servicing, give you *extra* long service life.

There are *Texaco Meropa Lubricants* for every type, size and speed of enclosed drive — including heavy-duty worm gears. They have exceptionally high load-carrying capacity, resist oxidation and thickening, have strong adhesive qualities, and do not foam.

Texaco Meropa Lubricants also prevent bearing corrosion, and do not separate in service, storage or centrifuging.

To keep high-speed strip mills operating dependably, keep circulating systems *clean* with *Texaco Regal Oils.* These turbine-grade, heavy-duty circulating oils resist sludge formation — so prevent costly stoppages.

For Texaco Products and Lubrication Engineering Service, call the nearest of the more than 2500 Texaco distributing plants in the 48 States, or write The Texas Company, 135 E. 42nd St., New York 17, N. Y.

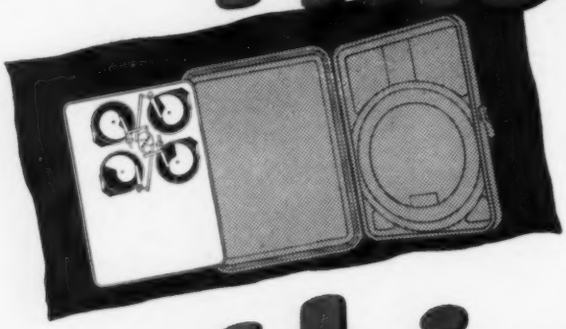
TEXACO

TEXACO Meropa Lubricants

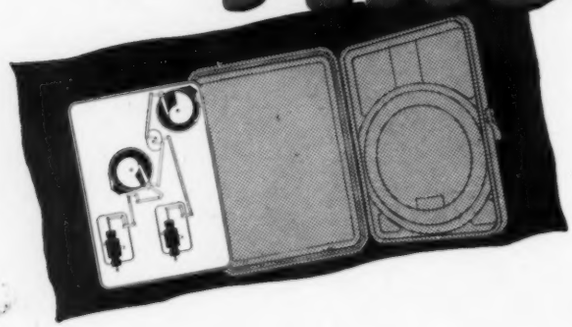
FOR STEEL MILL REDUCTION GEARS

Tune in...Texaco Star Theatre every Wednesday night featuring Gordon MacRae and Evelyn Knight...ABC Network

you can have this



...or this



or 100,000 other instrument combinations

... with 4 circuits ... 8 basic parts ...

P-18-S

More than 100,000 different instrument combinations are now possible from four basic circuits and eight basic component parts. That's how Bailey has simplified electronic controls for processing industries.

No matter what your process may be, you can use Bailey controls for flow, temperature, pressure, level, speed, gas analysis, pH, conductivity, etc. Four circuits and eight basic parts are all you need. You don't have to carry a large stock of replacement parts. Bailey parts are interchangeable. The units you use for one control can quickly be adapted to another.

To learn how Bailey controls can save you money and speed up control installations, write for a copy of Bailey Bulletin No. 17.

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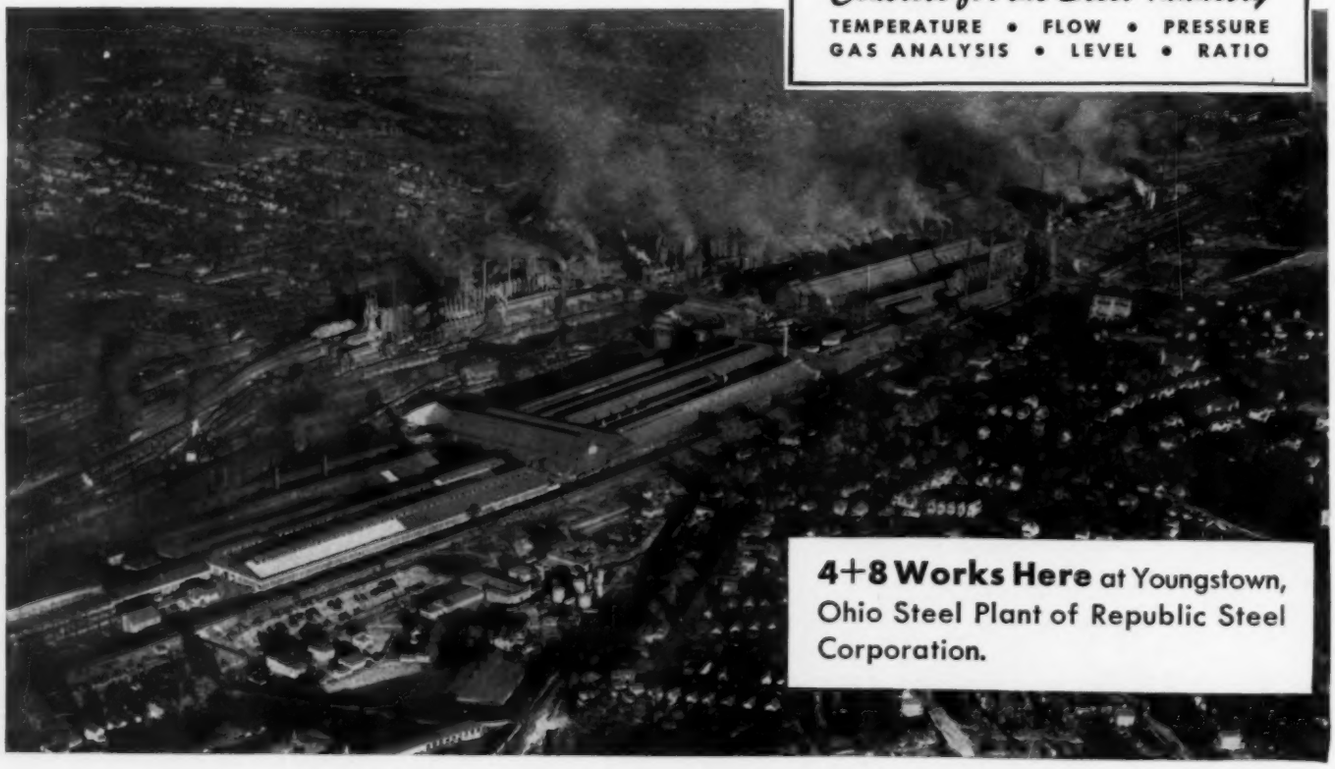
BAILEY METER CO. LIMITED, MONTREAL

Controls for the Steel Industry

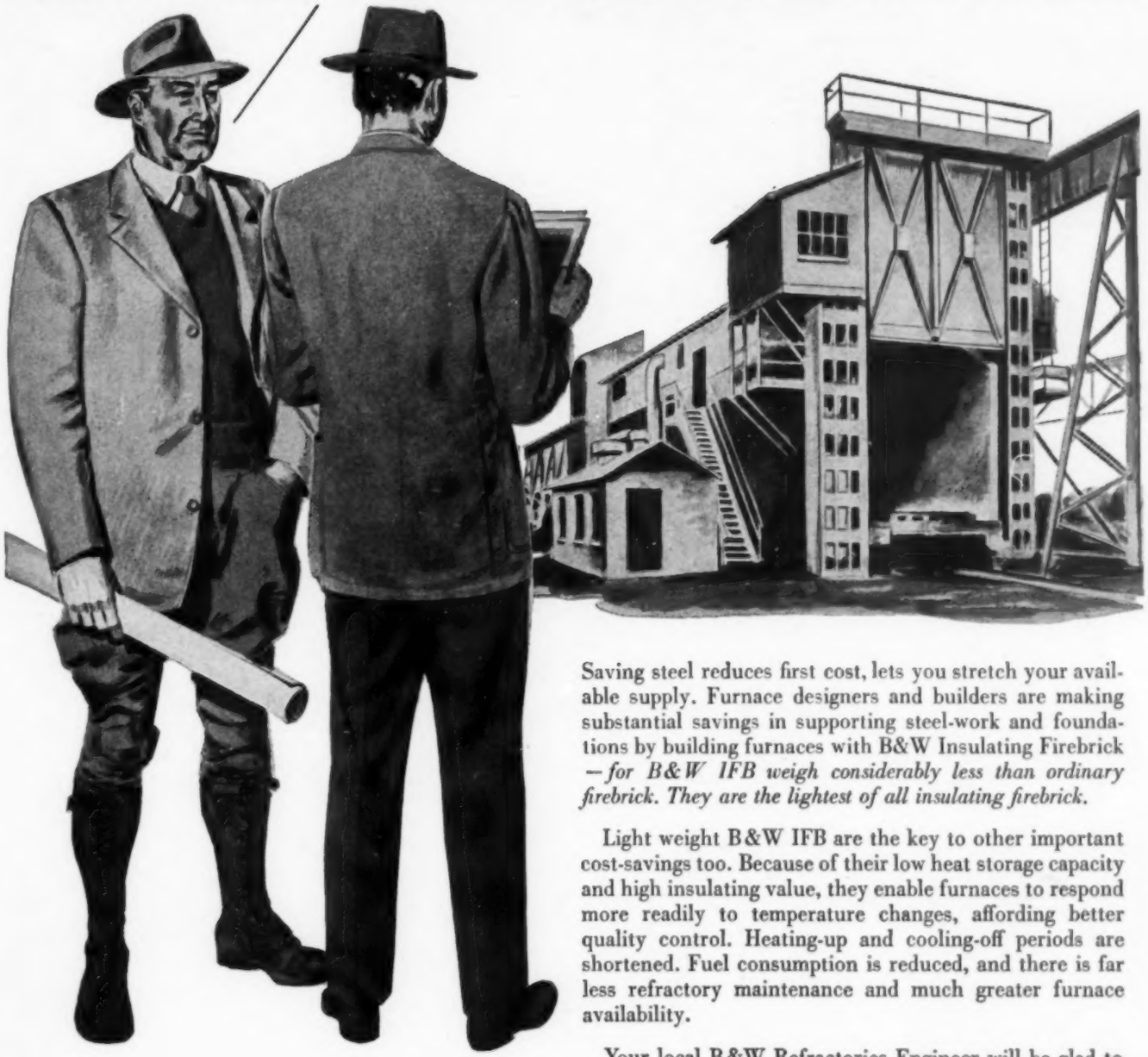
TEMPERATURE • FLOW • PRESSURE
GAS ANALYSIS • LEVEL • RATIO



4+8 Works Here at Youngstown, Ohio Steel Plant of Republic Steel Corporation.

And you save on steel-work, too, by using

LIGHTWEIGHT B&W INSULATING FIREBRICK



Saving steel reduces first cost, lets you stretch your available supply. Furnace designers and builders are making substantial savings in supporting steel-work and foundations by building furnaces with B&W Insulating Firebrick —*for B&W IFB weigh considerably less than ordinary firebrick. They are the lightest of all insulating firebrick.*

Light weight B&W IFB are the key to other important cost-savings too. Because of their low heat storage capacity and high insulating value, they enable furnaces to respond more readily to temperature changes, affording better quality control. Heating-up and cooling-off periods are shortened. Fuel consumption is reduced, and there is far less refractory maintenance and much greater furnace availability.

Your local B&W Refractories Engineer will be glad to show you how B&W Refractories products may contribute to lower first cost and greater overall production efficiency in *your* furnaces.

R-220

B&W REFRACTORIES PRODUCTS

B&W 80 FIREBRICK • B&W JUNIOR FIREBRICK
B&W 80 GLASS TANK BLOCKS • B&W INSULATING FIREBRICK
B&W REFRACTORY CASTABLES, PLASTICS AND MORTARS

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BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 85 LIBERTY ST., NEW YORK 6, N.Y.
WORKS: AUGUSTA, GA.

That depends on production schedules . . . but today, when demand is up . . . you can't afford to lose valuable production time.

Wagner type CP totally-enclosed, fan-cooled motors are designed for a particular purpose—to operate efficiently in atmospheres filled with dust, fumes, moisture and other agents that quickly ruin open type motors.

Steel mill operators have found from experience that it pays to use Wagner CP Motors—they stay on the job, requiring no maintenance other than periodic lubrication, in spite of the destructive elements in the surrounding atmosphere. You will find CP motors a lasting investment in continuous, troublefree motor performance.

More than fifty-five years of experience stands behind every motor bearing the Wagner name. Nationwide service facilities are available to users of Wagner Motors.

Call any of our twenty-nine branch offices, located in principal cities and manned by trained field engineers, for advice on all of your motor problems. Bulletins on the complete line of Wagner Motors will be sent upon request.

Wagner
type CP **Motors**

This totally-enclosed, fan-cooled polyphase motor has all vital parts sealed in an inner frame.

Wagner Electric Corporation
6483 PLYMOUTH AVE., ST. LOUIS 14, MO., U. S. A.

Consult Wagner Engineers on all Electric Motor Problems

Wagner Electric Corporation
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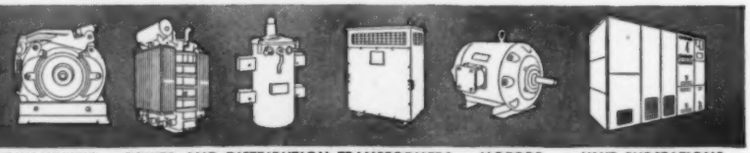
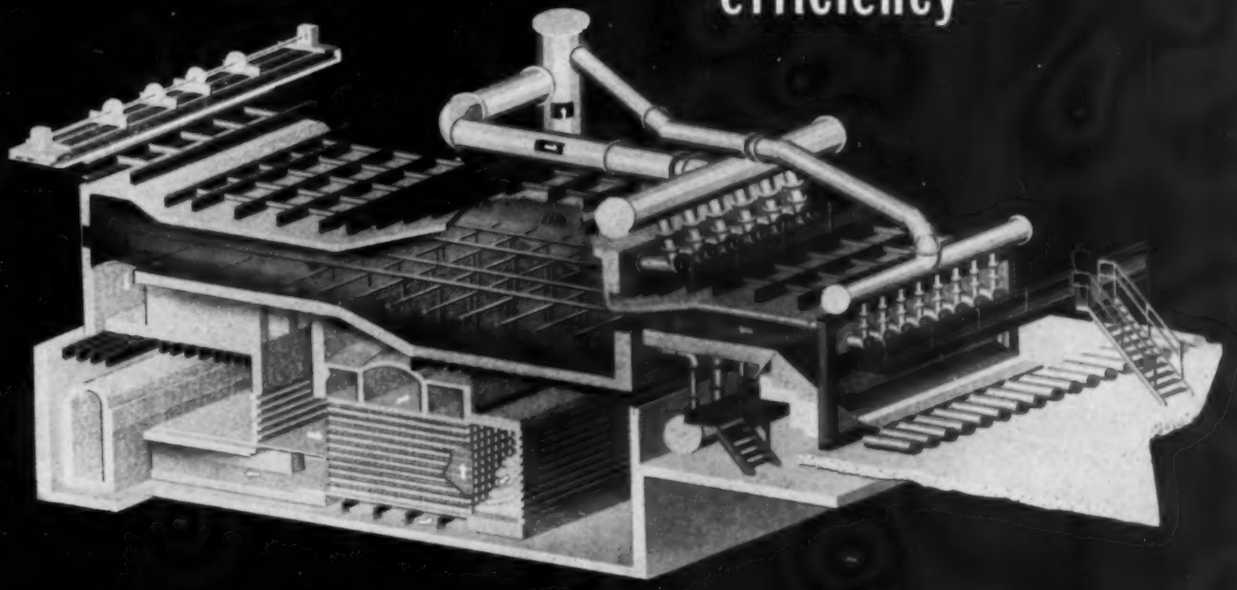


BRIDGE BRAKES • POWER AND DISTRIBUTION TRANSFORMERS • MOTORS • UNIT SUBSTATIONS
ELECTRICAL AND AUTOMOTIVE PRODUCTS

M48-20

There's only one way to assure heating efficiency—



LOOK INTO

RUST *ZONE-CONTROLLED* CONTINUOUS FURNACES

for reheating blooms, slabs, billets, bars . . .

ONLY ONE TYPE of continuous furnace provides perfect control of the heating operation from start to finish. That's the Rust Zone-Controlled Recuperative Continuous Furnace with independently fired heating and soaking chambers. Built in tandem, they assure control of tonnage output, heating quality and 100% accuracy in control of predetermined heating temperatures.

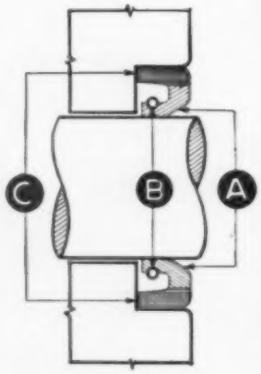
Roof design at charging end of heating chamber allows for expansion, thus reduces velocity and eliminates bleeding of waste gases. Flexibility of output is achieved by changing rate of fuel fired. Soaking chamber heat remains constant for any specific rolling temperature, gives uniform heat distribution with a minimum of fuel. Consult a Rust expert now on Double and Triple-Fired type furnaces for heating light and heavy sections.

RUST FURNACE CO.
PIONEERS IN FURNACE DESIGN
PITTSBURGH, PENNSYLVANIA

THE WHOLE JOB IS ONE JOB WITH A RUST "PACKAGE" CONTRACT

One Rust contract covers everything . . . from blueprint to test-run. Rust assumes responsibility for design, manufacture and erection of all essential material . . . including not only excavations, foundations and wiring, but all work connected with tables, pushers, controls and other equipment. Your purchasing and engineering departments are freed of subcontractor headaches when you order from Rust.

EVER SEE AN OIL SEAL AS SIMPLE AS THIS ONE?



Here's how *Clipper Seal* works:

The flexible lip (A) is held in light but firm contact with the shaft by means of the garter spring (B). Pressure on shaft is carefully pre-determined to minimize wear, yet effectively seal against leakage. The rigid heel (C) provides a press fit in the cavity, assuring a tight lubricant-retaining seal at this point also. This design is readily varied to meet special conditions.

JM

THE JOHNS-MANVILLE CLIPPER SEAL consists of only two parts—a one-piece moulded body and a specially designed garter spring, factory-assembled into a single compact unit.

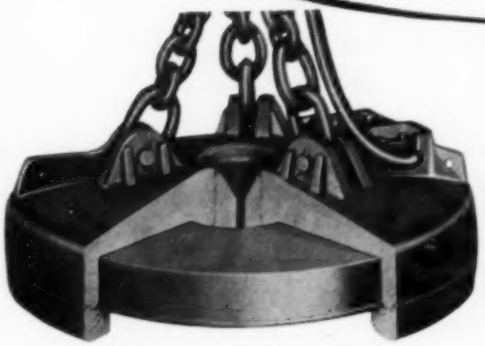
This simple design, so different in principle, provides advantages not found in most conventional type oil seals. It permits unusual compactness and economy in designing oil seal cavities. It allows greater bore tolerances—since no metal case is used. It offers high corrosion-resistance—since Clipper Seal's body is entirely non-metallic. And it assures positive sealing with efficient, long-term bearing protection in a wide range of industrial oil seal applications.

Clipper Seals are made in both split and endless types and are available for shafts up to 66" in diameter. They are recommended for sealing against oil, grease, water, air, grit and coolants at operating temperatures up to 450° F.

For further information, write for brochure PK-31A. Address Johns-Manville, Box 290, New York 16, N. Y.

Johns-Manville **PACKINGS & GASKETS**

The Type SW *All Welded* Magnet Construction Preserves Coil Life and Maintains Lifting Ability



Double-sealed against moisture —a water-tight coil within a water-tight housing.

No air-gaps—No cored holes for pole shoe bolts — instead, solid rings of metal which do *not* loosen from the magnet-housing.

PROLONGING magnet-life by keeping moisture out of the coil has been the goal of magnet engineers for years. EC&M has mastered this problem in the Type SW All-Welded magnet design. The coil, when wound on its steel spool, is jacketed in a steel case (Fig. 1 above). After vacuum-treatment, filling with No. 282 compound which is thermally-set by baking, this moisture-resistant unit is sealed into the magnet-housing by continuous welds (Fig. 2 above). Only the EC&M Type SW Magnet has this *double protection* for longer coil-life.

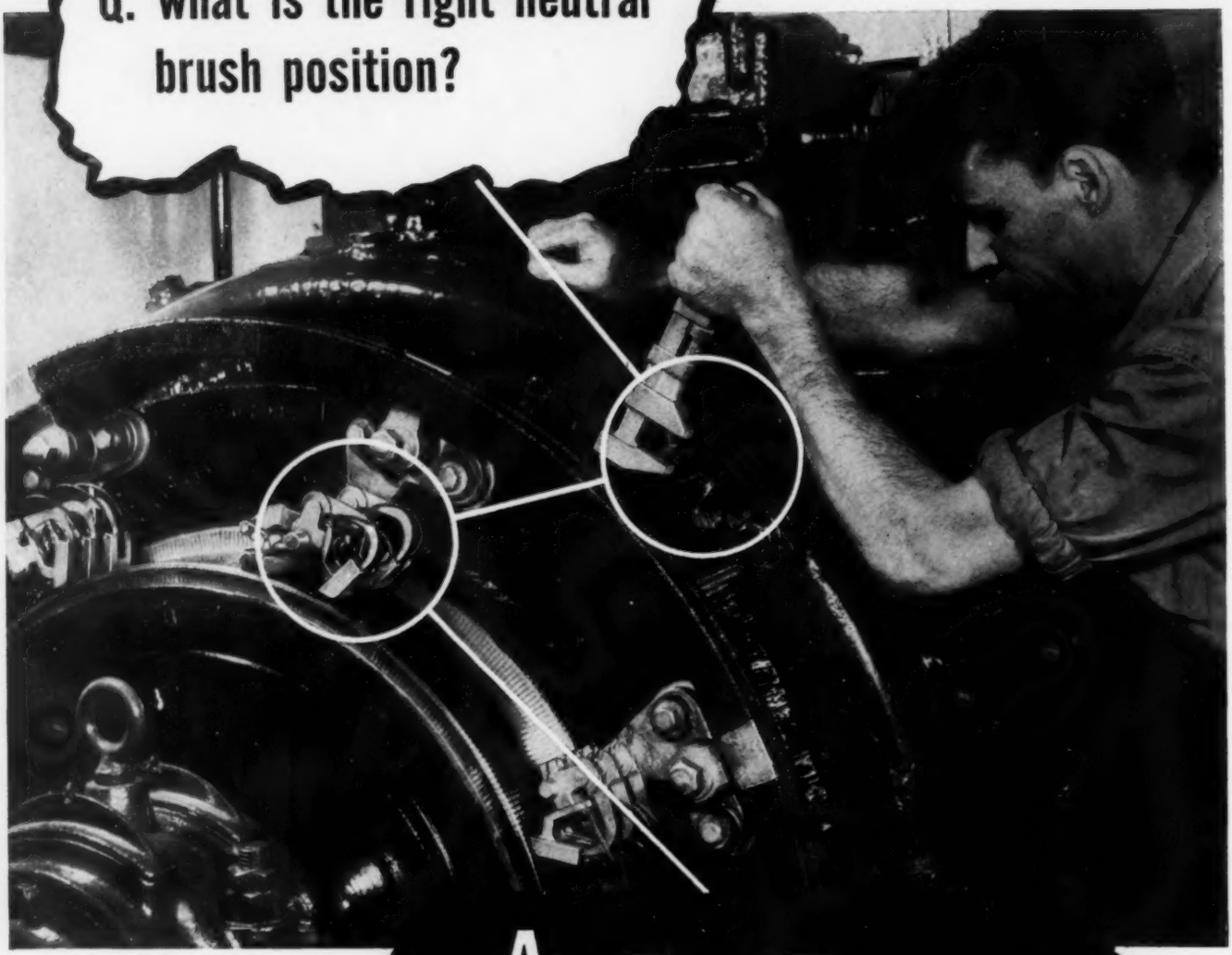
Eliminating air-gaps at the pole shoes has likewise been a troublesome expense to users of bolted magnets. Welds have often been added on outer shoes to keep the outer magnetic path tight, independent of the outer bolts, but center pole shoes were not designed to permit welding. The Type SW All-Welded magnet completely solves this problem—inner and outer shoes are held securely in place throughout their long life (Fig. 3 above). Air gaps do not form—either shoe can be renewed without extensive cleaning or truing up of mating magnet-surfaces—the tight SW construction preserves these surfaces for a snug fit. Only EC&M's Type SW Magnet has *both pole shoes* welded to keep lifting ability at top efficiency.

Type SW — an *All - Welded* Magnet of advanced design. Bulletin 900 shows the details which give *high output at low upkeep*. Write for your copy today.

THE ELECTRIC CONTROLLER & MFG. CO.

2698 EAST 79th STREET ★ CLEVELAND 4, OHIO

Q. what is the right neutral brush position?



A- See Speer!

For best commutation, brush holders must be set at the right neutral position, especially when units have been rewound. In generators, this point is ahead of the no-load position, in motors it is behind. The exact neutral position is determined by one of four accepted methods, any of which Speer's engineering department is prepared to apply to your problems. It is also vitally important that the right brushes be selected.

The Speer Carbon Company, makers of top-quality carbon brushes for over 50 years, is prepared to survey your operation. Our engineers will recommend brushes for best all-around performance. Call the Speer man and profit from his experience and knowledge.

Speer

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brushes · contacts · welding electrodes · graphite anodes · rheostat discs · packing rings · carbon parts

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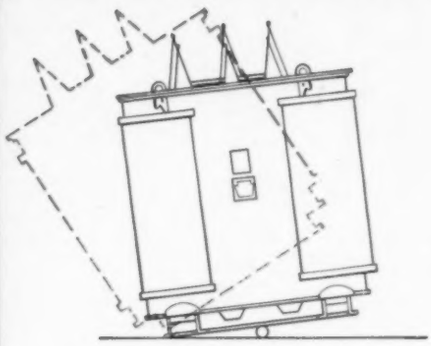
Again it's PENNSYLVANIA

This Time with a Definitely NEW, IMPROVED BASE for Single and Three Phase Power Transformers

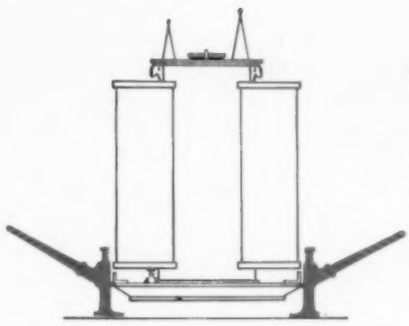
After a thorough study of customer requirements, Pennsylvania Engineers have perfected a base design to meet the needs of the greatest number of transformer users.

NOW, Pennsylvania presents the ultimate in transformer base construction, again illustrating Pennsylvania's versatility and its regard for solving basic transformer problems.

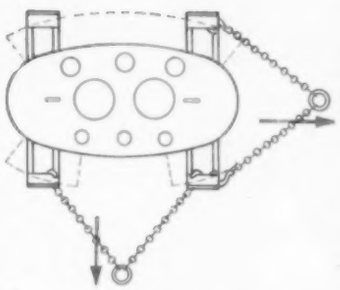
3750 Kva, 3 Phase, 60 Cycles, OISC, 55°C 12000△-2400△/4160Y volts. Inert Gas, Oil-Seal System.



TIPPING Base design takes into consideration transformer's center of gravity. The largest rolls used cannot tip transformer past its center of gravity.

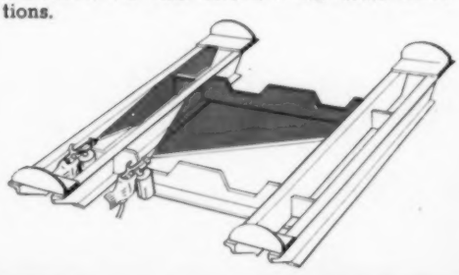


JACKING Structural base members extend to ends of radiators. Radiators offer no interference to jacking. Clearance provided for base of jack to extend under jack lugs. This allows toe of jack to enter all the way under jack lug, and exert the full strength of the jack on the transformer.



PULLING Jack lugs are constructed so that a standard hook can be placed in the jack lug to pull the transformer in any direction. Radiators offer no interference when transformer is pulled.

PAINTING Ports are provided in base members to ventilate bottom of transformer tank, and to facilitate complete painting of the base and tank bottom. Rust will not attack the tank bottom under these conditions.



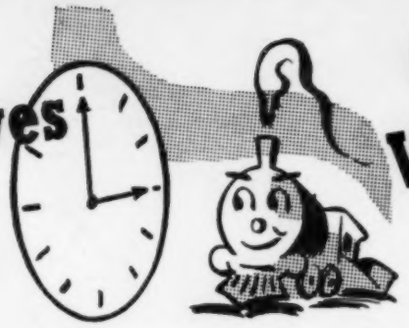
Pennsylvania TRANSFORMERS

Pennsylvania

TRANSFORMER COMPANY

808 RIDGE AVENUE • PITTSBURGH 12, PA.

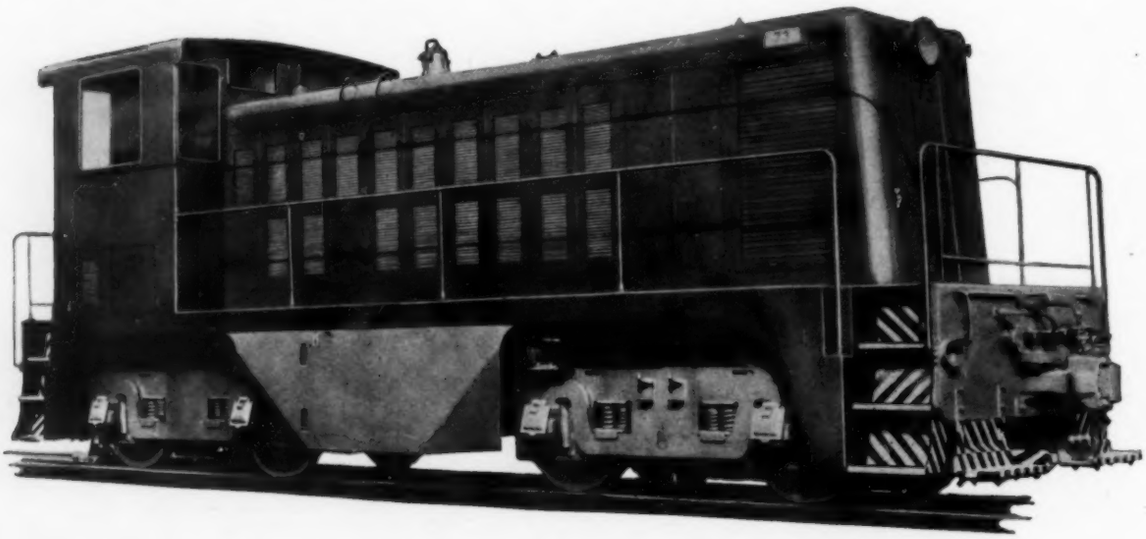
Are your locomotives CLOCK WATCHERS?



Then switch to Diesel

WHITCOMB LOCOMOTIVES

LET'S LET THE RECORDS SPEAK: They show, among their other important advantages, that Whitcomb Industrial Diesel Electric and Diesel Mechanical Locomotives ARE AVAILABLE almost 100% of every 24 hours! That's a FACT taken from the records. And an *important* fact to those who invest in industrial locomotives, because switching and hauling services assigned to them must be performed at *any* and *all* times. The power supplied by Diesel engines is always on tap—plenty of power for starting heavy loads, hauling long drags and getting back in a hurry. WHITCOMB LOCOMOTIVES are versatile and adaptable; operating costs are surprisingly low, and maintenance costs less than you would reasonably expect.



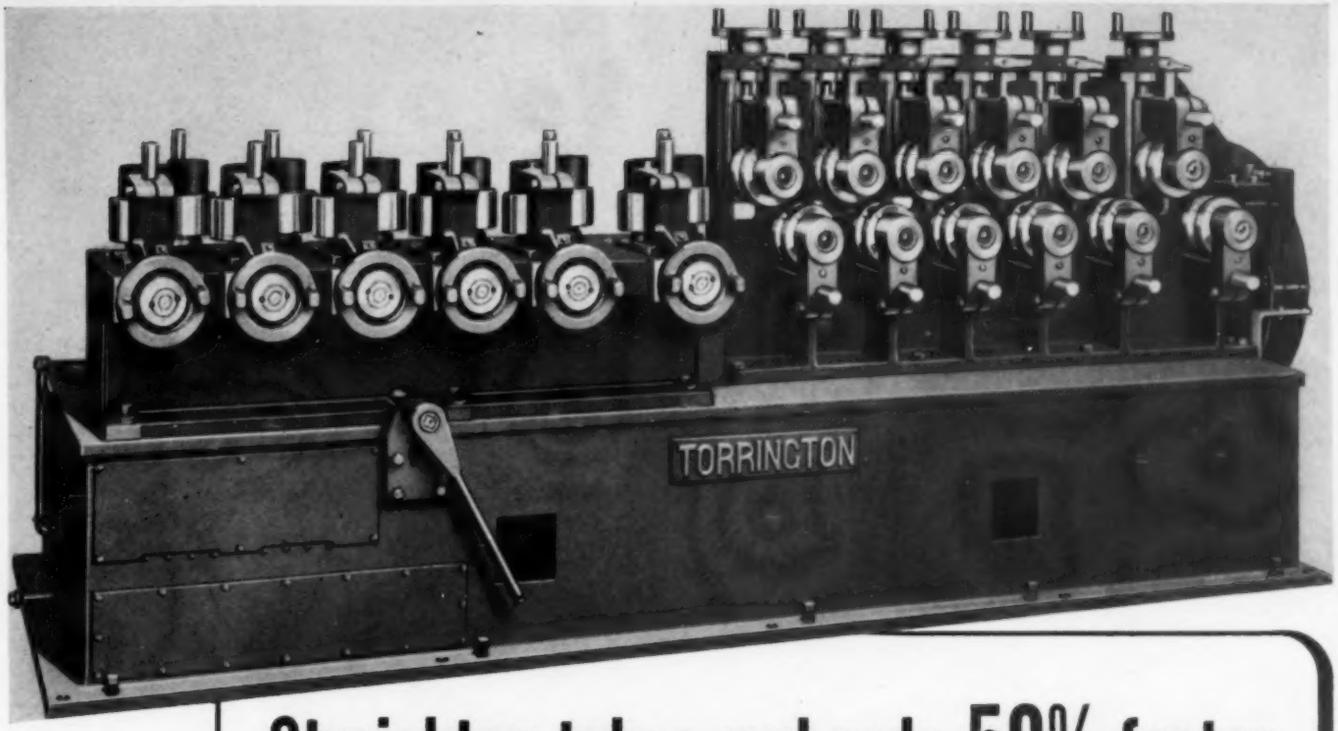
Diesel Electric and Diesel Mechanical Locomotives to 95 Tons

THE BALDWIN GROUP

THE WHITCOMB LOCOMOTIVE CO.

ROCHELLE, ILL.

Subsidiary of THE BALDWIN LOCOMOTIVE WORKS



Straighten tubes and rods 50% faster with this 24-roll Torrington Straightening Machine

● Step up production and lower your costs in the tube and rod straightening department with Torrington's 1738 Straightener. High-speed straightening is soundly engineered into every detail of this machine . . . including its 24 rolls which assure accuracy without the necessity of a second run.

The entire machine is built compactly on a rigid, all-welded steel base. All gears are of special alloy steel, teeth hardened and ground, totally enclosed and running in oil for speed, long life and quiet operation. Drive to adjustable rolls is provided through universal joints. All roll arbors are mounted in anti-friction bearings. Extra strength is engineered into this Torrington Straightener to insure ample margin of protection against possible overload strains during operation.

Round, square, rectangular or hexagonal shapes are straightened with equal success and speed. Suitable rolls are available for each type and the machine is designed for fast, simple setup for various diameters and shapes.

The basic design has been adapted to both 12- and 24-roll straighteners with capacities ranging from 1/16" to 4" in round tube diameters and in proportional sizes for other shapes. For complete details and engineering data on Torrington Straighteners, ask your Torrington representative, or write us directly, stating your approximate requirements.

THE **TORRINGTON**
MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT

FIRING BIG FURNACES WITH GAS?
A Micromax "Team" Will Dole It Out—Accurately!

The Spang-Chalfant Division of The National Supply Co. heat-treats big batches of two-ton drill collars in this efficient Hagan Furnace. Its Micromax Controllers regulate temperatures accurately — and thriftily. Circle shows couples and burner ports; below is Micromax Control room.

Accurate and thrifty control for big, multi-zone furnaces requires a pyrometer setup which has a quality one might call "teamwork." Here are some of the ways we provide it:

1. Pyrometers can be either Micromax or our new Type G Speedomax, depending on requirements of the process and preference of the user. We'll help with the selection if you wish; either instrument will give the reliable performance which L&N potentiometers pioneered and have maintained for almost a generation.

2. Each instrument can be initially set to the exact requirements of its furnace zone . . . no matter how widely these vary. Each then holds temperature on the mark, regardless of changes in load, ambient temperature, etc.

3. No attention is required to keep all Controllers at the same accuracy. Each standardizes itself every forty-five minutes. All members of the "team" are therefore always accurately in step.

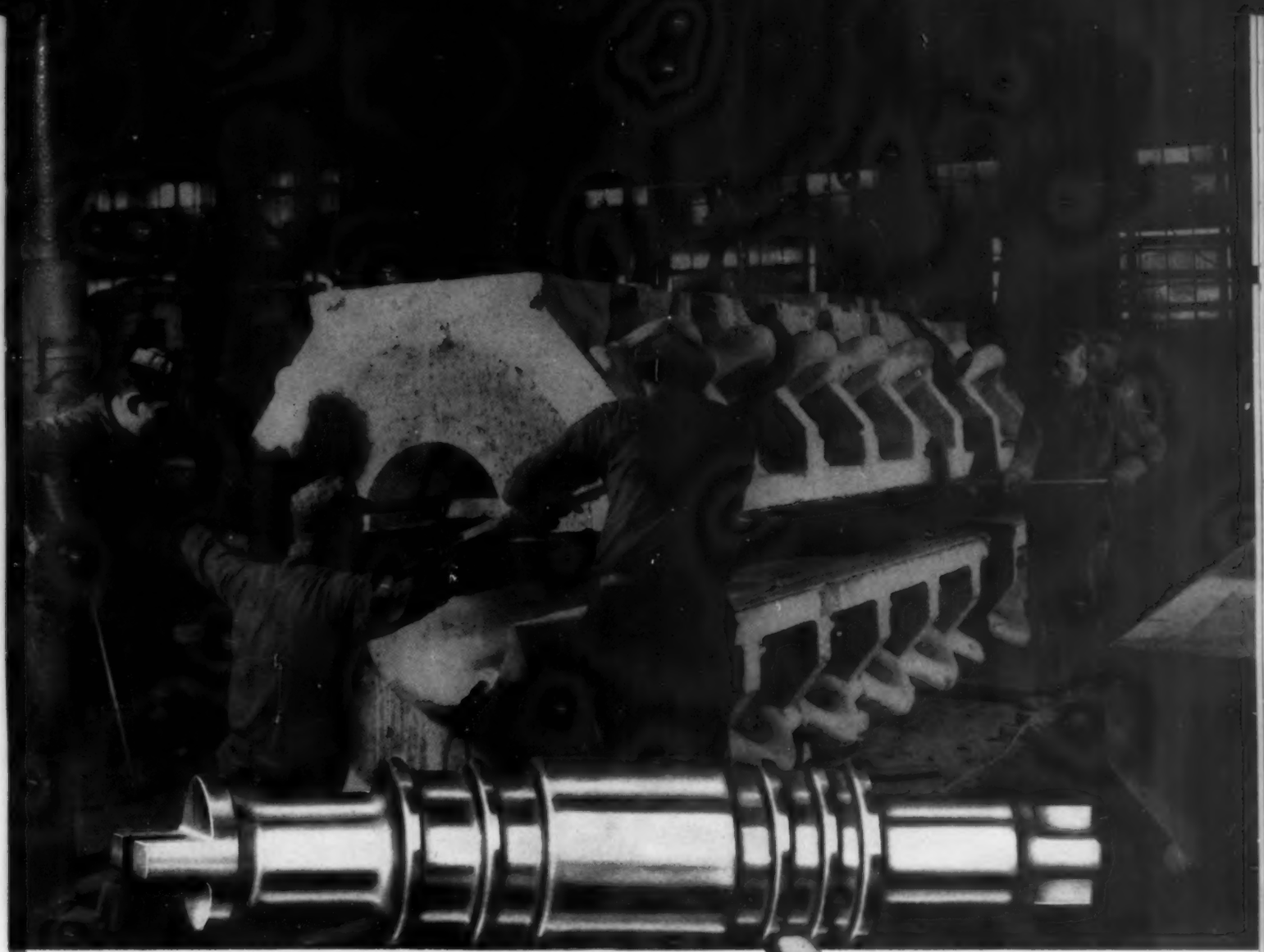
4. Efficient combustion, proper furnace atmosphere and correct furnace pressure can all be tied into the L&N temperature control for cost-cutting operation at high production levels.

For further information, write Leeds & Northrup Company, 4942 Stenton Avenue, Philadelphia 44, Pa.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · AUTOMATIC CONTROLS · TELEMETERS
HEAT-TREATING FURNACES

Jrl. Ad N-33A-621(1)



Preparing the mold for casting Phoenix Alloy Steel Rolls

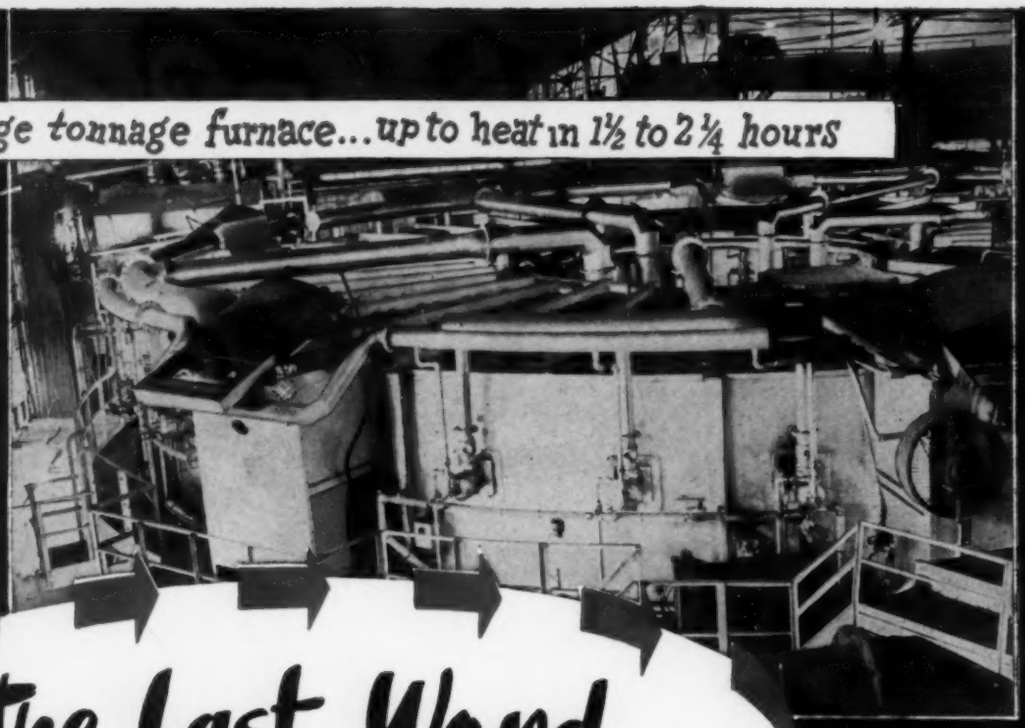
PHOENIX ROLLS FOR THE BLOOMING MILL

Whether of plain carbon steel for extreme strength, or of Phoenix "A" Alloy Steel where unusual wearing qualities are desired, Pittsburgh rolls will produce blooms, billets, and slabs *at less cost per ton of steel rolled.*

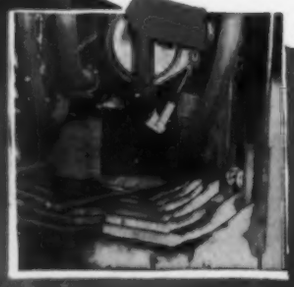
PITTSBURGH ROLLS

DIVISION OF BLAW-KNOX COMPANY, PITTSBURGH 1, PENNSYLVANIA

large tonnage furnace... up to heat in 1½ to 2¼ hours

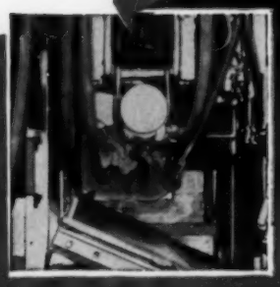


The Last Word in a Rotary Hearth Furnace



At Left: Charge port showing cold bar entering furnace.

At Right: Heated bar being discharged.



Here is a large tonnage production Rotary Hearth Furnace which can be brought to full heat in 2¼ hours time. (On occasions it has been done in 1½ hours.)

It is a 5-zone furnace, fully automatic, and has combination oil and gas firing, with pressure control, and each zone has independent combustion and temperature control, all of which give optimum flexibility in quality control heating, suitable for all grades of steel.

This furnace now operating in The Babcock and Wilcox Tube Company's plant, features B & W light refractory throughout. Like all other Salem furnaces of giant size, this one is Timken Bearing equipped.

Salem Engineering Company

HEADQUARTERS FOR HEAT TREATING DESIGN

Salem, Ohio *Southwest Office, Fort Worth, Texas*

R-7

SALEM ENGINEERING (CANADA) LTD., TORONTO, ONT. • SALEM ENGINEERING COMPANY, LTD., SHEFFIELD, ENGLAND

PRODUCT *Information*

ON ANY OF THE PRODUCTS MENTIONED IN THIS ISSUE

Below is an index of products referred to in editorial and advertising pages of this issue. If you desire additional information on any of them, use one of the accompanying postcards in requesting it. In each case give name of product and page number. The information will come to you directly from the manufacturer involved.

PRODUCTS INDEX

Air filters 161
Annealing box charger 140
Annealing furnaces 21
Anti-friction bearings 143, 147, 196
Atomizers 158

Bar and tube turner 166
Batteries, storage 155
Bearings, anti-friction 143, 147, 196
Bearings, laminated 180
Bearings, roll neck 147, 153
Billet chippers 27
Boxes, charging 149
Brushes, carbon 10, 170
Buckets 152
Burners 179

Cables, insulated wires and 23, 145
Carbon brushes 10, 170
Chains, magnet suspension 144
Charger, annealing box 140
Charging boxes 149
Conduit fittings 137, 174
Contacts, moving power 32
Controls, combustion 4, 14, 156
Controls, electrical 26
Cooling towers 184
Couplings, flexible 20
Crane cab conditioner 158, 164, 175
Crates and baskets, pickling 154
Cranes 25, 30, 144

Drives, generator 188
Drives, twin 28

Fans 151
Filter, air 161
Filter, pipe line 33
Filter, vacuum 150
Firebrick, insulating 5
Furnace, car-type 156
Furnaces, electric arc 36
Furnaces, reheating 7
Furnaces, rotary 16
Fuses 138, 181

Gears, worm 172
Graphite 150
Grinder, roll ..... Cover 1, 24
Guides, mill 169

Heaters, radiant 168
Heaters, unit 148, 160

Industrial trucks 22
Inhibitors, pickling acid 146

IRON AND STEEL ENGINEER August, 1948

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IRON AND STEEL ENGINEER

1010 EMPIRE BUILDING

PITTSBURGH 22, PA.

PRODUCTS INDEX — (Continued)

Insert roll die....166
Instruments....4, 14, 156
Insulated wires and cables....23, 145

Locomotives, diesel....12
Lubricants....3, 191
Lubricating equipment....178

Magnet, lifting....Cover II, 9
Marking machine....160
Mill equipment, rolling....34, 157
Mills, rolling....157
Mills, sizing....1
Monel metal....187
Motors, electric....6, Cover IV

Packings and gaskets....8
Paint, industrial....162
Pickling crates and baskets....154
Pipe cleaning....163, 177, 183
Piping equipment, power....176
Plasterguard....160
Pumps, turbine....162

Reducers, speed....Cover III
Resistors, steel grid....190
Roll die, insert....166
Roll grinder....Cover 1, 24
Roll neck bearings....147, 153
Rolling mill equipment....157
Rolls....2, 15, 19

Safety steel stamps....148
Saws, friction....173
Shear, flying....152
Sizing mills....1
Soapstone....158
Solvent, cold....158
Speed reducers....Cover III
Stamps, safety steel....148
Straightening machine....13
Switchgear....159

Tape, splicing....167
Timer, pneumatic....158
Transformers....11
Trucks, industrial....22, 146
Tube turner, bar and....166
Tuyeres....179, 181

Unit heaters....148, 160

Welding machine, submerged arc....165
Wires and cables, insulated....23, 145
Worm gears....172

IRON AND STEEL ENGINEER August, 1948

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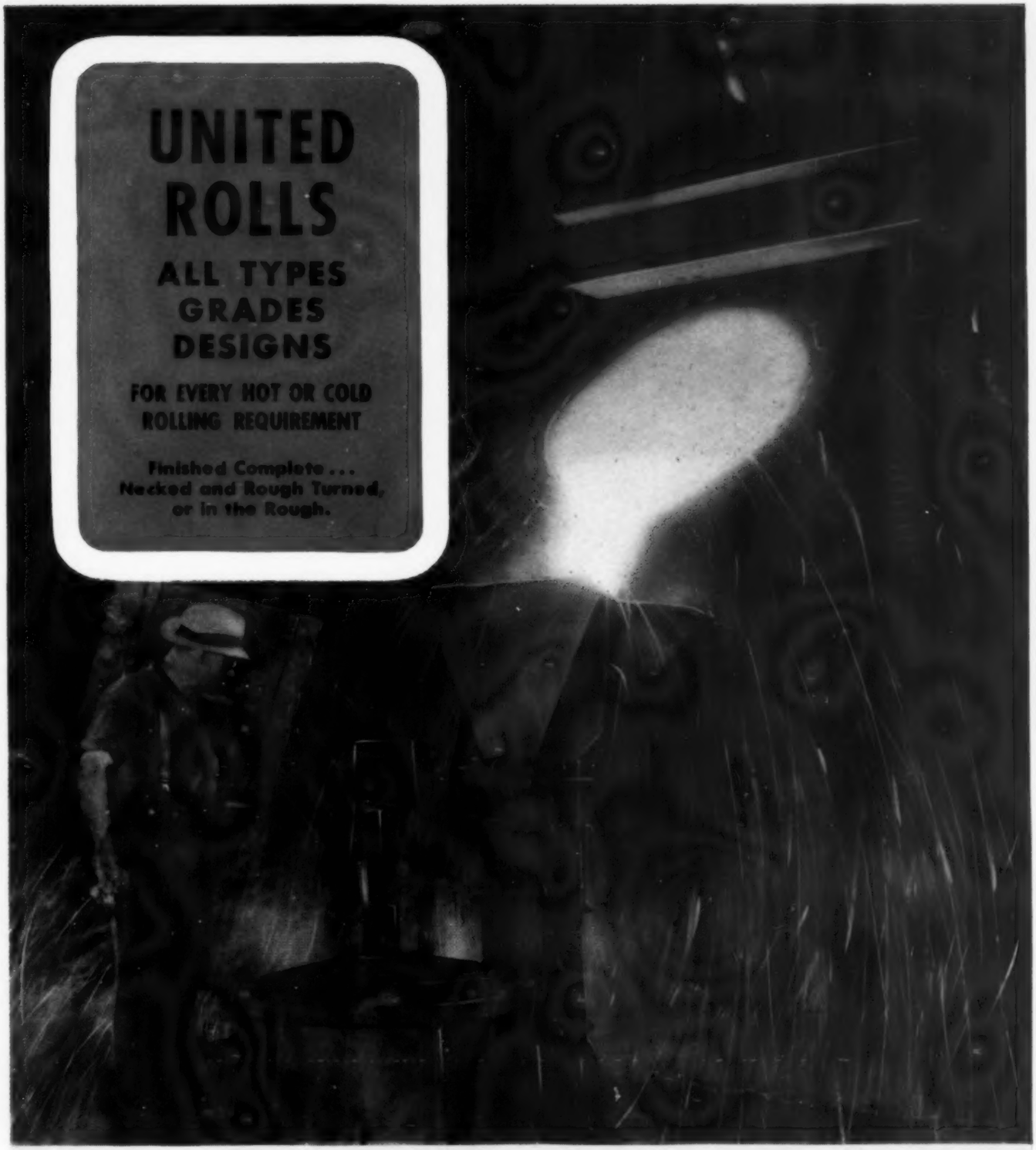

UNITED ENGINEERING and FOUNDRY COMPANY

PITTSBURGH, PA.

Plants at PITTSBURGH · VANDERGRIFT · NEW CASTLE · YOUNGSTOWN · CANTON

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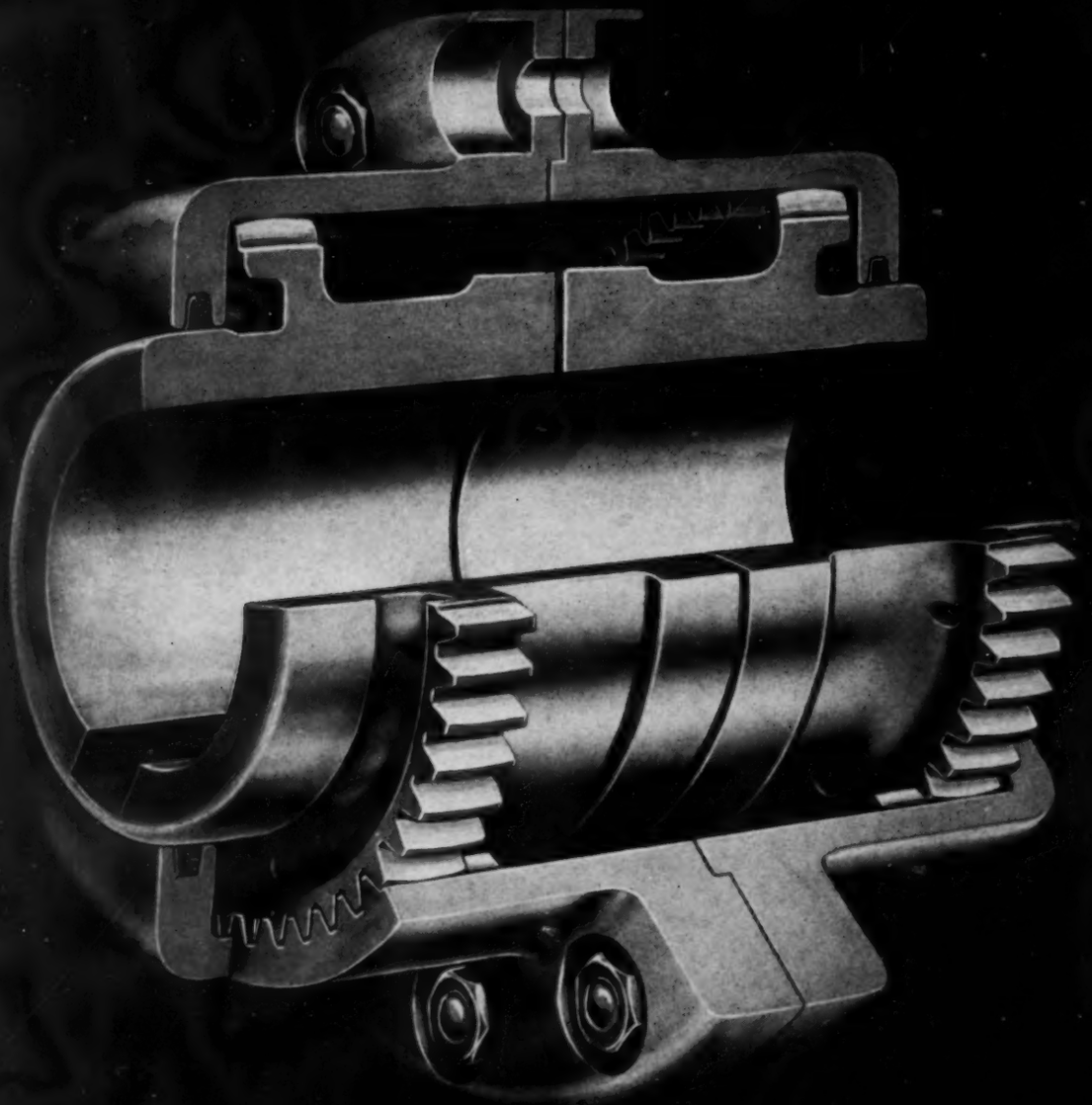
Designers and Makers of Rolls and Rolling Mill Equipment

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

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ILSON ANNEALING FURNACES AT THE KAISER COMPANY, INC. NARROW STRIP MILL at FONTANA, CALIFORNIA
ENGINEERED AND CONSTRUCTED BY THE
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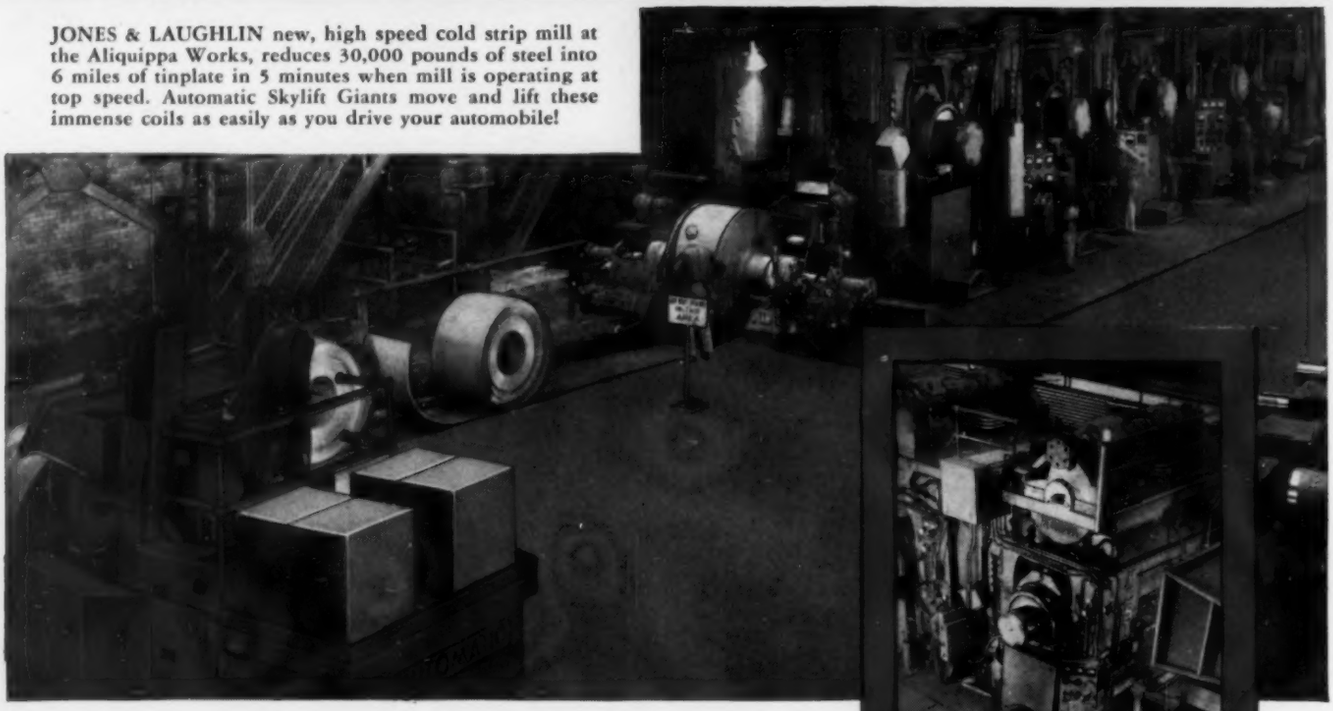
ENGINEERING Co., Inc.
20005 West Lake Road CLEVELAND, OHIO
Telephone ACademy 4670
INDUSTRIAL FURNACES
RADIANT TUBE HEATING
HEAT TREATING PROCESSES
THESE 5 RADIANT TUBE FIRED FURNACES ARE HEATED WITH VAPORIZED LIGHTWEIGHT FURNACE OIL

What makes you think Your Product is too unwieldy to handle WITH AUTOMATIC ELECTRIC TRUCKS?

JONES & LAUGHLIN new, high speed cold strip mill at the Aliquippa Works, reduces 30,000 pounds of steel into 6 miles of tinplate in 5 minutes when mill is operating at top speed. Automatic Skylift Giants move and lift these immense coils as easily as you drive your automobile!



Skylift GIANTS

MOVE AND LIFT 30,000 POUNDS OF UNWIELDY STEEL COIL

THERE'S AN AUTOMATIC TRUCK TO FIT *YOUR* PRODUCT . . . TO CUT YOUR HANDLING COSTS 'WAY DOWN!

Steel mills no longer are limited in production speed by the size of coils that can be delivered to and discharged from the mill—because Skylift Giants handle all sizes and weights of coils. One operator lifts and moves 30,000 pounds as easily as you shift gears in your car.

No matter what your product—and how cumbersome *you may think it is to handle*—there's an Automatic model to bring your business the same kind of money-saving handling it brought the steel industry.

Automatic Electric Trucks will end gruelling, back-breaking manual handling in your plant. Exclusive *high pressure* hydraulic lift permits moving and tiering in low clearance box cars and trucks. Yet you also can stack your material up to 130 inches high. Burn-out proof Silicone Insulated Motors prevent motor failure due to overheating.

Mail coupon. Let us show you how Automatic miracles of electric power can earn you miracle savings in handling operations.

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Please mail me, without cost, complete facts on how I can cut my material handling costs with Automatic Electric Trucks.
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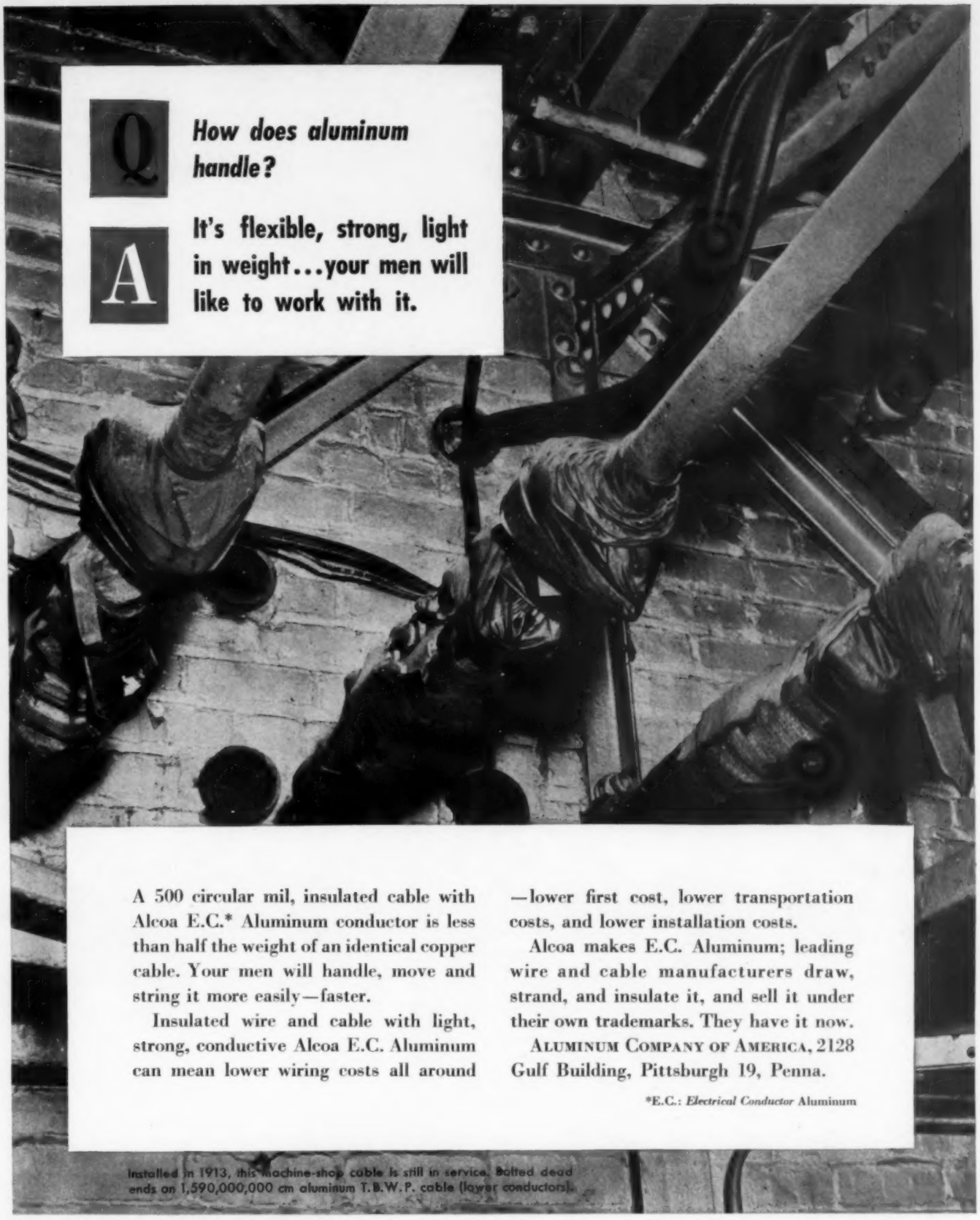
MANUFACTURERS OF THE FAMOUS TRANSPORTERS, TRANSTACKERS AND SKYLIFT ELECTRIC TRUCKS



Q ***How does aluminum handle?***

A **It's flexible, strong, light in weight...your men will like to work with it.**

A 500 circular mil, insulated cable with Alcoa E.C.* Aluminum conductor is less than half the weight of an identical copper cable. Your men will handle, move and string it more easily—faster.

Insulated wire and cable with light, strong, conductive Alcoa E.C. Aluminum can mean lower wiring costs all around—lower first cost, lower transportation costs, and lower installation costs.

Alcoa makes E.C. Aluminum; leading wire and cable manufacturers draw, strand, and insulate it, and sell it under their own trademarks. They have it now.

ALUMINUM COMPANY OF AMERICA, 2128 Gulf Building, Pittsburgh 19, Penna.

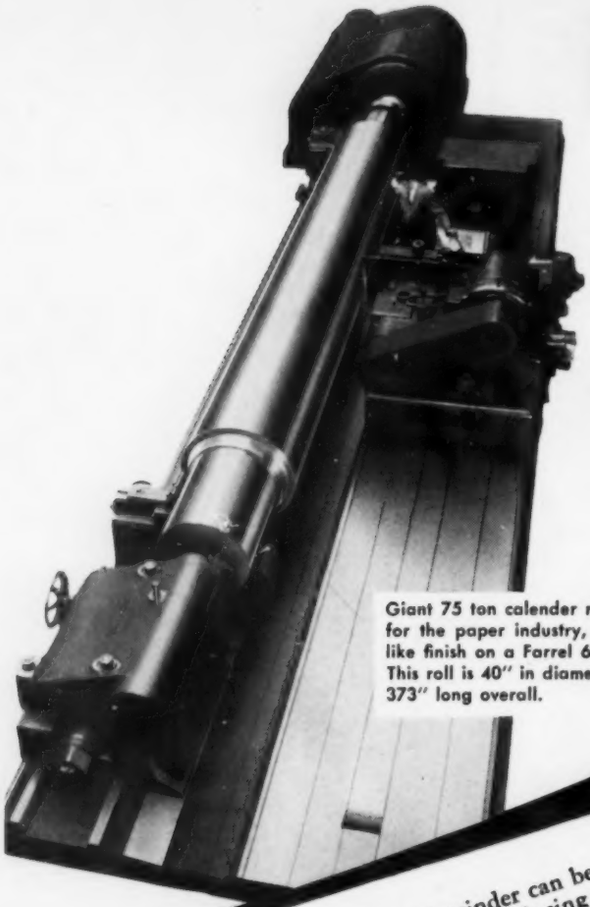
*E.C.: *Electrical Conductor* Aluminum

Installed in 1913, this machine-shop cable is still in service. Bolted dead ends on 1,590,000,000 cm aluminum T.B.W.P. cable (layer conductors).

ALCOA EC ALUMINUM

FOR ELECTRIC WIRE AND CABLE

why *Farrel* grinders bring roll maintenance costs down



Giant 75 ton calender roll, heaviest ever produced for the paper industry, being ground to a mirror-like finish on a Farrel 60-inch, heavy duty grinder. This roll is 40" in diameter, has a 276" face and is 373" long overall.

HIGH OUTPUT — A Farrel roll grinder can be used for either heavy roughing or producing as high a mirror finish as it is possible to obtain with wheels at present available. It is extremely fast on both types of work.

EASE OF SET-UP AND OPERATION — Many automatic features assure simplicity of set-up and operation. Setting-up time is held to a minimum.

HIGH ACCURACY — Grinds straight, convex or concave rolls. A mathematically accurate curve, symmetrical on both halves of the roll, is produced for either a convex or concave shape without manipulation by the operator. The same setting invariably produces exactly the same curvature and permits fixed, uniform and easily controlled accuracy of contour in all rolls.

SIMPLIFIED TAPERING — When tapered journals are required, the machine (equipped with a special tapering attachment) will grind both necks and finish grind the body without disturbing the original setting of the roll.

For the story of "how" all these roll maintenance helps are possible, write for Bulletin No. 115 which describes in detail the many features of the Farrel heavy duty roll grinder. A copy of this NEW *bulletin will be sent to you without cost or obligation.*

1848 FARREL CENTENNIAL 1948

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONN.

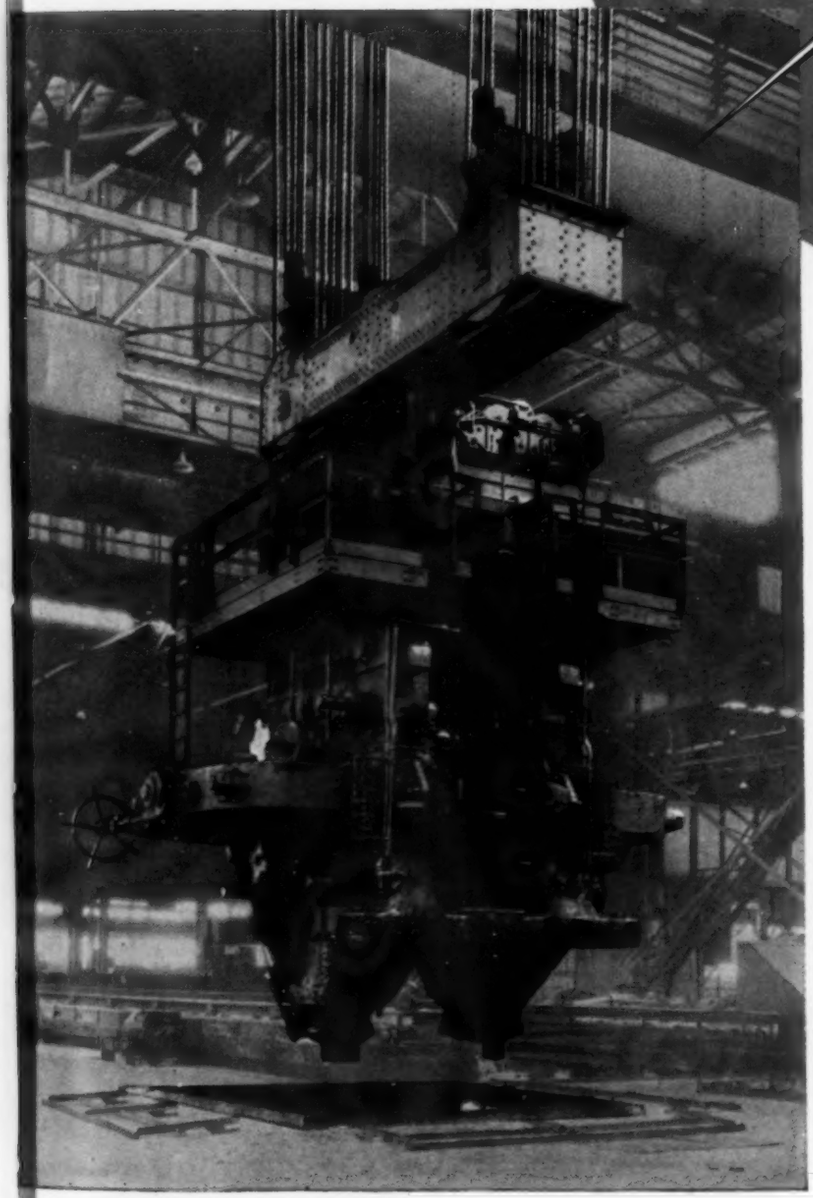
Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Chicago, Los Angeles, Tulsa, Houston

Farrel-Birmingham

FB-472

Alliance . . .

LEADER IN THE FIELD OF *Crane Design* FOR HALF A CENTURY



Shown here is a 300-ton, 4 Girder, Double Trolley ALLIANCE Crane. It has a 300-ton Main Hoist, a 40-ton, and a 5-ton Auxiliary Hoist.

• Are you handling heavy loads . . . moving slabs, ingots, hot metals, raw materials, or finished products? Then your plant needs sturdy, *efficient* Alliance cranes to handle these tough jobs safely, quickly, and easily. Developed by the world's largest builders of the world's largest cranes, Alliance equipment is built for long, rugged service . . . designed to give you unsurpassed, economical lifting power wherever it's needed in your plant.

Alliance specialists have studied materials handling problems for 50-odd years . . . have designed and developed thousands of cranes to handle all types of loads in many different industries. Let Alliance engineers show you how to maintain smooth-flowing production schedules with less cost, less effort, less maintenance work.

★

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS
SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET
CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES
SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION

THE ALLIANCE MACHINE COMPANY

MAIN OFFICE:
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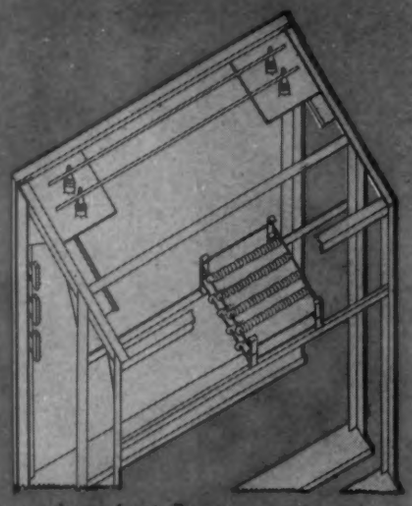
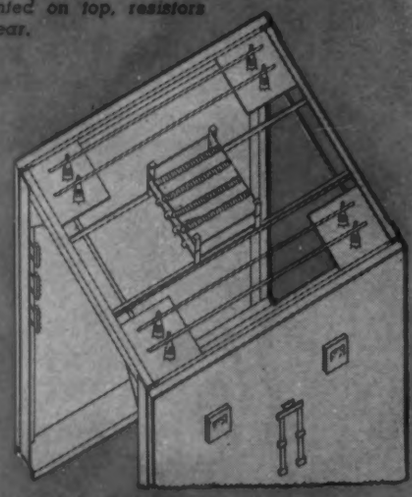
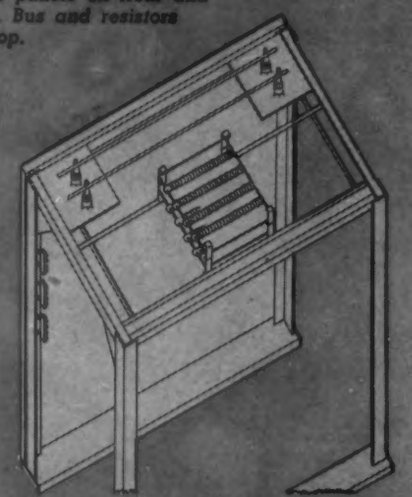


Slate panels on front. Bus mounted on top, resistors on rear.



Slate panels on front and rear. Bus and resistors on top.



Slate panels on front. Bus and resistors on top.

CLARK Builds

FACTORY ASSEMBLED Mill Control

to Standard Designs or to Your Specifications

● Clark Factory Assembled Mill Control Panels provide unitized control. Resistors and other associated apparatus are completely mounted and wired. Much field work is eliminated from both wiring and erection. All power and control leads are brought to suitable terminals. Power busing to each panel eliminates field work.

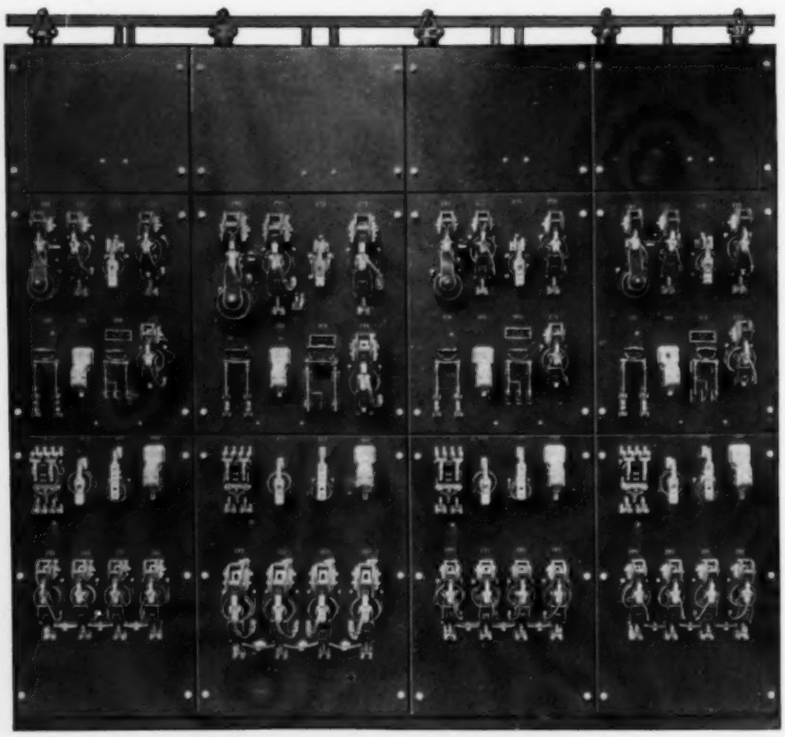
Each section is self-supported, uniform, and can easily be matched with later installations. Panels are built to standard designs or to customers' specifications.

FEATURES

1. UNITIZED CONTROL
2. MINIMUM FIELD WIRING
3. SIMPLY ERECTED
4. SELF-SUPPORTED
5. APPARATUS SELF CONTAINED
6. LEADS TO SUITABLE TERMINALS
7. POWER BUS AND RISERS

●

Our nearest District Office will give you complete details.

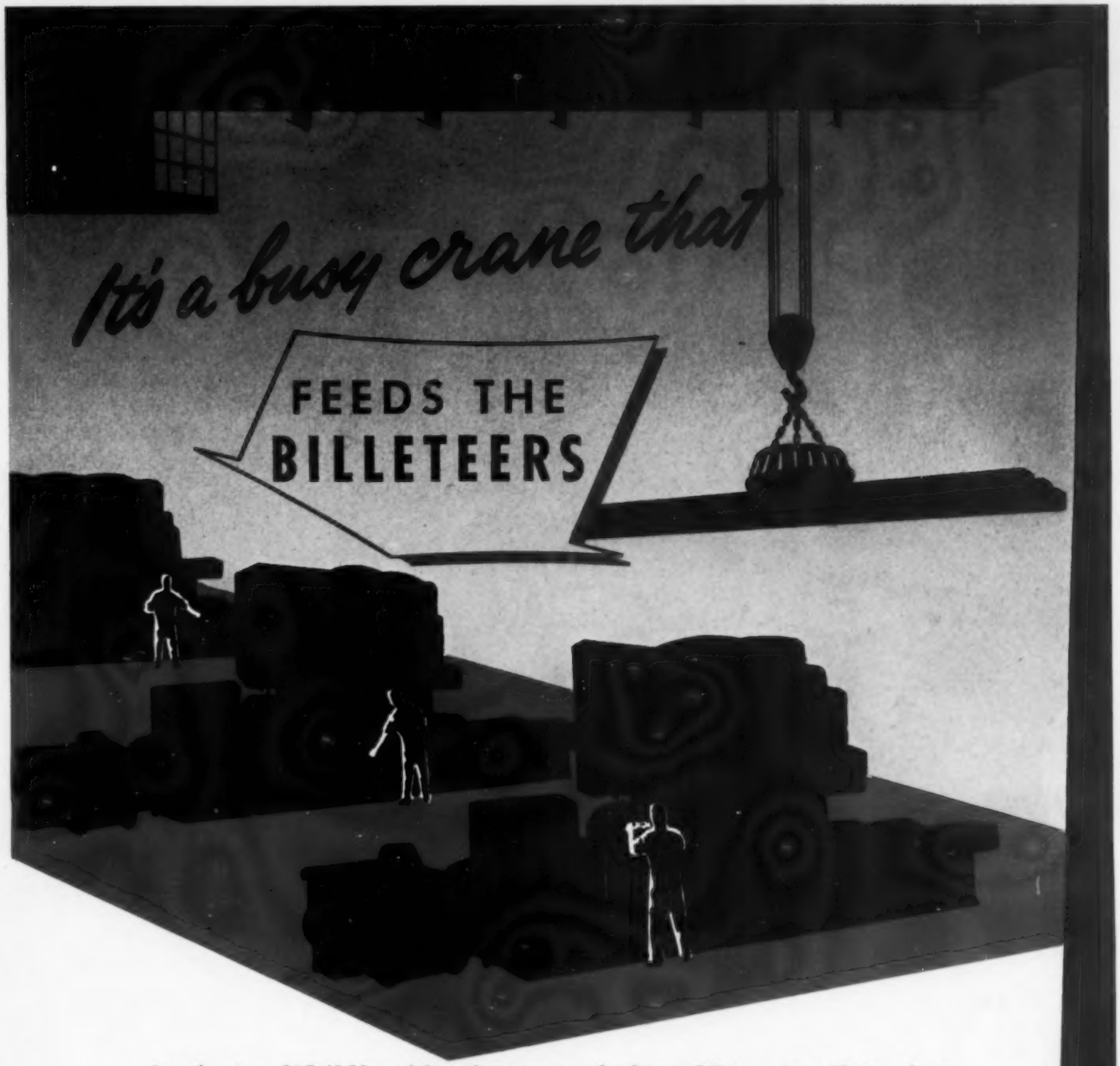


Front view—Typical Factory Assembled Panels.

EVERYTHING UNDER CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152nd STREET, CLEVELAND 10, OHIO



Actual tests on SAE 4150 steel show the operator of a Bonnot Billeteer chips 49 times faster than a man with a chipping hammer.

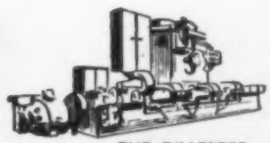
The smooth, steady operation of the Billeteer maintains a flow of clean billets ready for rolling. You can depend on the Billeteer, and large inventories are not necessary. Flaws one inch or more in depth are quickly cut out, salvaging steel that would have to be remelted in plants not equipped with this modern machine.

Bonnot Billeteers replace one of the most gruelling manual chores left in steel production, and do so at overall costs up to 50-60% under hand chipping costs.

Why not lick the manpower problem in your billet sheds by putting Bonnot Billeteers on your payroll? Complete information is furnished on request.

Engineered for Improved Production

The Bonnot Co.
STEEL EQUIPMENT DIVISION
CANTON 2, OHIO



THE BILLETEER

Modern Blooming-Slabbing Mill Uses G-E amplidyne-controlled TWIN DRIVES

Higher reversal and average speeds, larger tonnages made possible by amplidyne control of acceleration, deceleration, torque balance, and speed

In a large steel mill west of the Mississippi, one big reason for the 45-in. blooming-slabbing mill's high output is the G-E twin-motor reversing drive. Keyed to an adjustable-voltage amplidyne control system, this drive gives the operator an improved method of maintaining voltage for any given operating point, permits the higher average speeds that increase mill production. It also gives these specific advantages:

—**Provides** accurate control of acceleration and deceleration, maintaining maximum rates at all times. After running in one direction for a few revolutions, the mill can be quickly reversed (from base speed to base speed in 1½ seconds or less).

—**Assures** effective control of load limits, making maximum torque output of motors available as needed, for heavy passes at low speed and lighter passes at higher speed.

—**Reduces** the number of control devices required by about half, greatly simplifying the control scheme.

—**Maintains** accurate load balance between two or more machines operating in parallel, and proper torque and speed balance on both units of the twin-drive.

—**Keeps** motors and generators fully protected at all times against overcurrent, overvoltage, and overspeed for greater service continuity, longer equipment life.

—**Provides** definite, easily-selected speed points in both forward and reverse; permits low creeping speed to keep rolls turning slowly between passes for uniform cooling; eliminates creeping when necessary to line up couplings for changing rolls.

Whether you plan to install a new reversing-mill drive or modernize an existing one, General Electric can meet your need for higher speed and more accurate control. Call in a G-E steel mill engineer to talk it over. There's no obligation. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

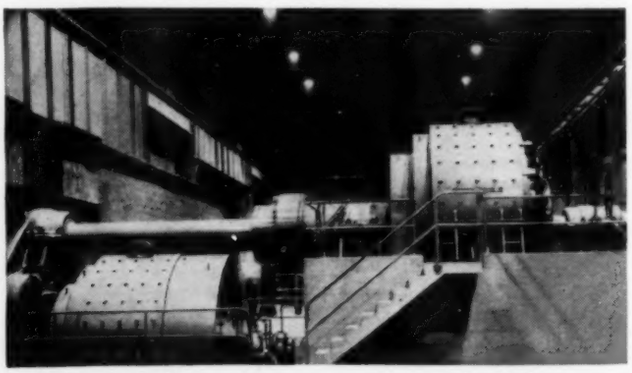
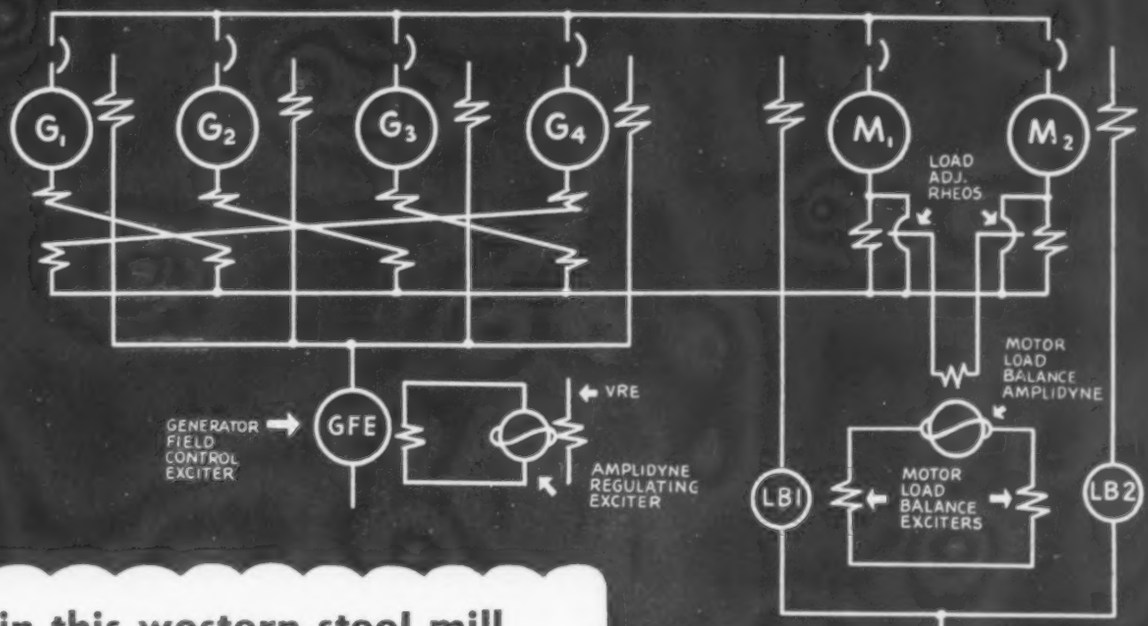


Photo shows the G-E twin-drive motors used in a 45" x 115" reversing slabbing mill. Each d-c motor is 5000 hp, 40/80 rpm, 750 volts.

GENERAL ELECTRIC

650-82

HOW THE G-E DRIVE WORKS . . .

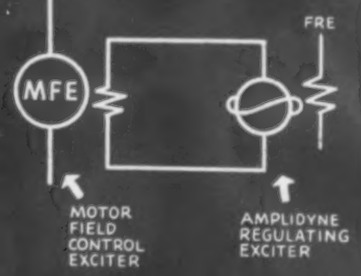


. . . in this western steel mill

The speed of the twin motors (M_1 and M_2) is varied by adjusting the voltage of the generators ($G_{1,2,3,4}$) from zero to full voltage for either direction of rotation. This is done by means of the generator field exciter (GFE) and the amplidyne regulating exciter (VRE). For higher speeds the fields of the motors are weakened by means of the motor field exciter (MFE) and the amplidyne regulating exciter (FRE).

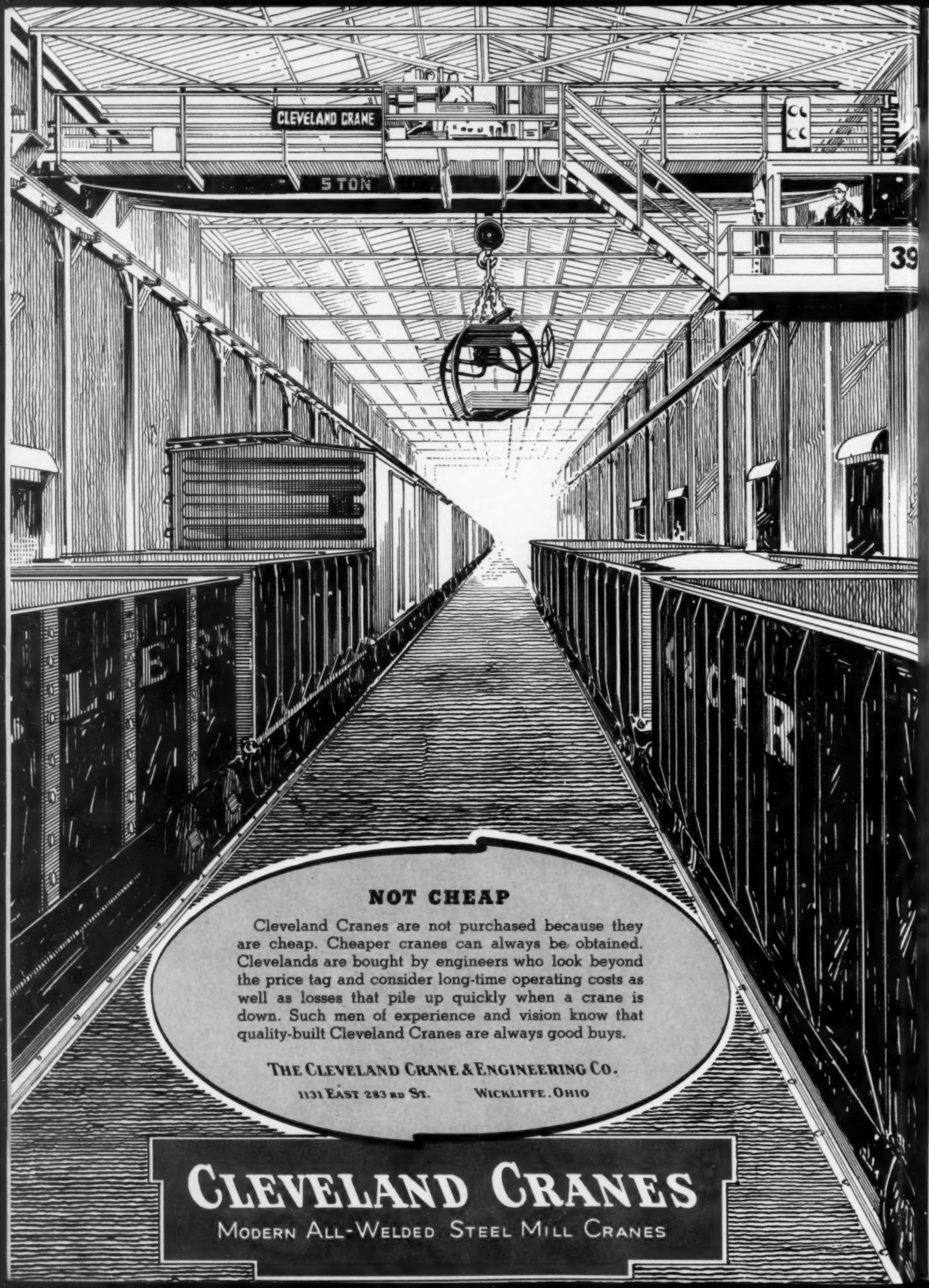
The regulating exciters (VRE and FRE) cause the twin motors (M_1 and M_2) and the mill to operate in a direction and at a speed determined by the position of the operator's master switch. In doing so, these amplidynes automatically limit the armature circuit current to a definite value. If, when operating with weakened motor fields, the operator tries to take an excessive draft, the amplidyne (FRE) acts to limit armature current. This it does by strengthening the motor fields, thereby supplying increased torque at lower speed.

Motor M_1 drives the upper work roll. Motor M_2 drives the lower work roll. Motor load balance amplidyne (LB) measures the difference between the two motor load currents. Amplidyne (LB) supplies excitation to the motor load balance exciters (LB_1 and LB_2) so as to strengthen the field of the motor carrying the higher load and weaken the field of the motor carrying the lower load. This restores the load current balance.



Schematic plan of armature and field circuits for G-E twin-motor slabbing mill drive.

another example of GE *drive engineering at work!*



NOT CHEAP

Cleveland Cranes are not purchased because they are cheap. Cheaper cranes can always be obtained. Clevelands are bought by engineers who look beyond the price tag and consider long-time operating costs as well as losses that pile up quickly when a crane is down. Such men of experience and vision know that quality-built Cleveland Cranes are always good buys.

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THAT noise you've heard lately stems from the old steel masters turning over in their graves as the steel industry, under compulsion of the U. S. Supreme Court's decision in the cement case, abandoned the 50 year old basing point system of prices and adopted f.o.b. mill prices, thus passing freight costs on to the steel consumers. The results of this change, which is generally deplored by steelmakers, steel users and economists, are difficult to predict. For the immediate future, the tight supply will keep steel users buying where they can get it, regardless of cost. When the future again brings competitive conditions, however, a reshuffling of customers might well occur. One might expect steel users, in time, to move their plants to the steel producing areas, and some such moves are already in evidence. This can spell hardship for many areas that might lose existing industries. On the other hand, it might be that steel producers will build new plants in large consuming areas. This latter move, although necessarily limited by the availability of raw materials in such locations, would satisfy somewhat the government's desire for the expansion of the steel industry.

Because the steel industry, by the very nature of its processes, must function through big plants, any particular decentralization into small scattered plants, with their uneconomical production, and therefore, higher prices, is unlikely. However, many steel fabricators can profit by decentralization. More fabrication at the mills can make an appreciable saving in freight as well as in back freight on scrap.

Certainly, shipping costs will be thoroughly investigated, and transportation methods will be overhauled. Greater use of water and truck shipments is expected. (Motorists will enjoy the latter).

When all the effects of this change have been felt and the repercussions registered, the disruptions may well be serious enough to bring about legislation that will again permit a basing point price system. What the steel industry desires is, in the words of B. F. Fairless, president of United States Steel Corporation, "the right to compete for business wherever we desire, without being told that we must or must not absorb freight charges."

▲

AFTER trying out to some extent the various systems, we have come to agree with the man who said: "The best way to get real enjoyment out of the garden is to put on a wide straw hat, dress in thin, loose-fitting clothes, hold a little trowel in one hand and a cool drink in the other, and tell the man where to dig."

FOLLOWING close on the heels of the third round of wage increases, which averaged about 9 per cent, or 13 cents per hour (ranging 9½-25 cents per hour), came steel price increases averaging about $9.34 per ton. After both raises, figures show that the average hourly wage in the industry has increased 105 per cent over the 1938 average, while the composite price of finished steel has gone up approximately 40 per cent, a much smaller increase than can be found in any other major commodity.

Many items in addition to wages have contributed to higher steelmaking costs. Heavy melting scrap has gone up 165 per cent, coal and coke 150 per cent, fuel oil 175 per cent. Raw material price increases range from 15-460 per cent, and freight costs have risen 27-62 per cent. And, perhaps more serious from the long range viewpoint, is the increase of 100 per cent or more in plant replacement costs.

▲

SCRAP prices surged to new highs in the wake of the increase in steel prices, with heavy melting scrap averaging more than $43 per ton.

▲

AFTER listening to radio broadcasts from three political conventions, we have decided that the logic of political speeches has more holes than a summer cottage roof. Particularly interesting was the Democrats' claim to credit for all the high wages and high national income, while attempting to foist all blame for high prices upon the Republicans. Politics is a wonderful thing.

▲

MIDDLE age has been defined as the time when a man stops wondering how he can dodge temptations and begins to wonder if he's missing any.

▲

MORE or less unnoticed in the shuffle attending the adjournment of Congress in June was the approval of legislation setting up federal control of stream pollution. It is understood that a principal target of this new control will be the Ohio River from Pittsburgh to Cincinnati. With a great portion of the steel capacity along this river and its tributaries, the steel industry will be called on for considerable expenditures to overcome their waste problems.

▲

ACCORDING to L. A. Umansky in a paper before the AIEE, the steel industry now uses about 200 kwhr of electric power per net ton of ingots produced. Approximately half of this is generated in the plants, and half is purchased from public utility companies. Twenty-five years ago, the proportion was two-thirds generated, one-third purchased.

▲

PROMOTED by the sales and service committees of the National Machine Tool Builders Association and the American Machine Tool Distributors, a two-week refresher course was held at Cornell University for 60 machine tool builders and dealers. This is yet another example of the growing tendency for industry to use higher educational facilities to develop the abilities of some of their key men, and enthusiastic reports on such projects indicate that the practice will expand in the future.

▲

AUTOMOBILE production for the first half of 1948 totaled 2,623,807 units, as compared to 2,474,-223 units in the first half of 1947.

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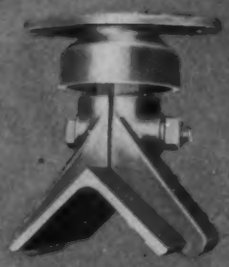

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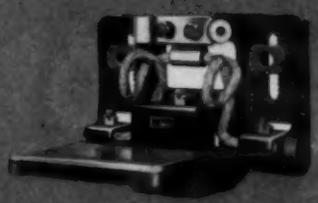

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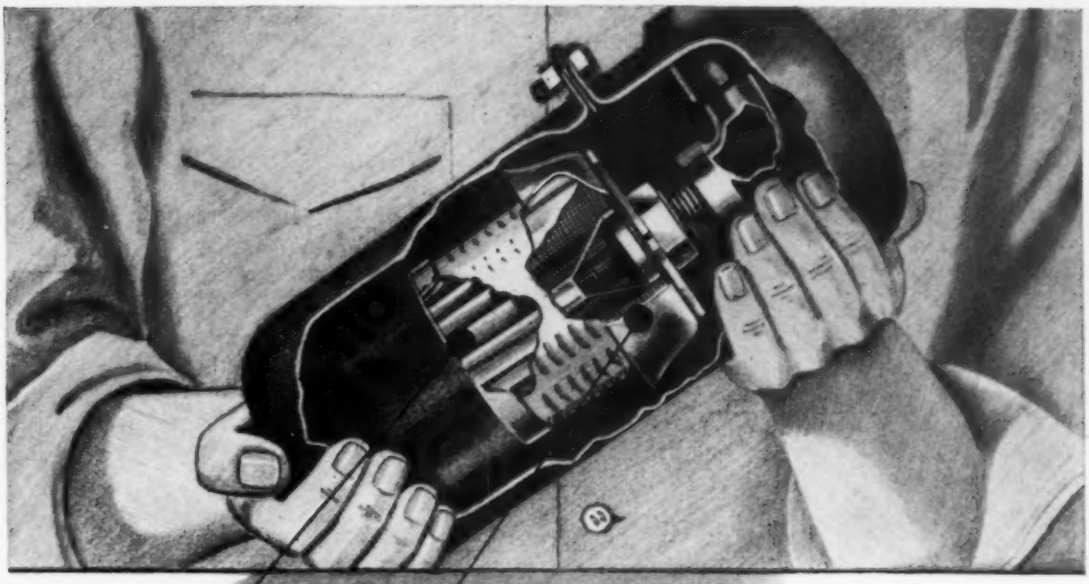

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AUGUST 1948 VOLUME XXV NUMBER VIII

In This Issue

Product Information 17

The Art of Rolling Hexagons and Octagons — by Charles P. Hammond, Superintendent Rolling Mills, Atlas Steels Limited, Welland, Canada 37

Discussion: The Art of Rolling Hexagons and Octagons — presented by Ross E. Beynon, C. P. Hammond, S. D. Gladding and S. C. Read 49

Industrial Uses of Some Polyether Synthetic Lubricants — by W. H. Millett, Carbide and Carbon Chemicals Corporation, Tonawanda, New York 51

Discussion: Industrial Uses of Some Polyether Synthetic Lubricants — presented by S. C. Griffith, J. H. Lewis, R. A. Kraus, W. H. Millett, C. E. Pritchard, J. D. Lykins, J. E. Sullivan and R. S. Shoemaker 58

Controls for Multiple Fuels — by William F. Pray, Askania Regulator Company, New York 61

Electrical Heating of Steel Strip for Continuous Processing — by A. R. Ryan and F. E. Ackley, General Electric Company, Schenectady, New York 66

Discussion: Electrical Heating of Steel Strip for Continuous Processing — presented by R. M. Baker, Eli Shay, F. E. Ackley, F. O. Schnure, Joseph Vernon, Roland Bangert, M. D. Stone and A. J. Morgan 78

The Purchasing Agent's Changing Status — by Harlan E. Cross, General Purchasing Agent, Sloss-Sheffield Steel and Iron Company, Birmingham, Alabama 81

Discussion: The Purchasing Agent's Changing Status — presented by H. E. Cross 84

Continuous Gas-Radiant Fusion for Electrolytic Tinning — by C. E. Cunningham, Selas Corporation of America, Philadelphia, Pennsylvania 85

Steel Mill Applications of Electronic Control — by J. Raymond Erbe, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania 93

Continuous Flow Internal Pipe Pickling 102

Technical Program of the American Iron and Steel Institute 107

News Supplement 141

Personnel 171

Date Line Diary 185

AISE New Members 191

Book Reviews 194

Index to Advertisers 195

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THE ART OF ROLLING

Hexagons and Octagons

By CHARLES P. HAMMOND,* Superintendent Rolling Mills
Atlas Steels Limited
Welland, Canada

. . . . although modern mills and equipment produce tonnages and quality which previously would have seemed impossible, rolling procedures and principles are fundamental . . . .

▲ THIS paper outlines the various methods used in producing hexagon and octagon sections, including details as to practice, methods of procedure and equipment used. The paper will make no intentional references regarding the most desirable method or practice, since individual mill layouts and final end use of the material rolled is an important factor in deciding a suitable roll pass design. In comparing the rolling of hexagons with that of rolling rounds, a hexagon having wide, flat surfaces is less difficult to hold and, therefore, requires less guide support.

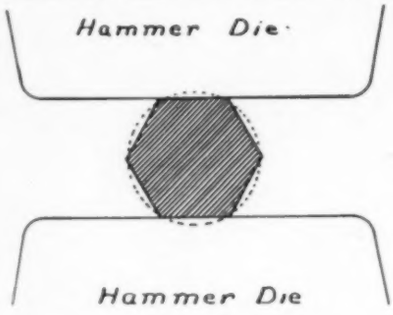


Figure 1 — In hammering a hexagon from a round bar, the round bar should be large enough to make a full section and a clean bar.

HEXAGONS

For many years, hexagons were hammered, especially the tool steel grades, since it was difficult for the mills operating in those days to roll the section with the necessary sharp corners. Most shops were equipped with hammers of various capacities which facilitated the scheduling of large sizes on a heavy unit and small sizes on very small hammers.

It was necessary that the hammerman be highly skilled, owing to the difficulty of producing a uniform section of flat dies (Figure 1). Maximum production from the hammer was obtained by the mill first producing a round billet. However, this required considerable forging skill and experience in starting the planes of each side correctly and in holding them parallel, especially on small sizes. The length of the bars usually ranged from 6 to 10 ft.

Hexagons are still being made under the hammer, especially on small orders of highly alloyed steels, where the quantity involved does not warrant a rolling setup.

Rolling hexagons by hand was one of the earlier methods used. However, since this method is obsolete, we will not dwell on any details pertaining to it. With today's procedure, the section is easily held in position by guides, due to the flat planes and corners which contact the rolls and they, in turn, tend to hold the bar in position without excessive wear on the guides. Hexagons are delivered from the finishing pass in two ways, according to the method adopted by the plant or mill.

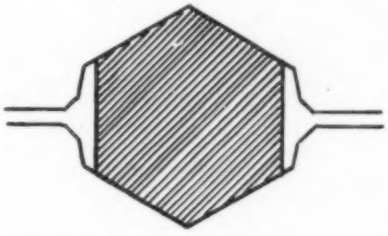


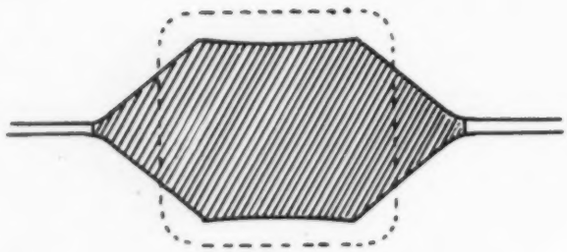
Figure 2 — The finishing groove is designed wider than the finished section to eliminate any chance of rubbing off the corners.

In the first method, the section is finished with a long diagonal running vertical. This is commonly termed as "points-down" (Figure 2). Producing hexagons by this method, from ¼ to $^{13}/_{16}$ in. requires the use of two passes. These are the finishing and leader passes with a 90 degree square entering into the leader pass (Figure

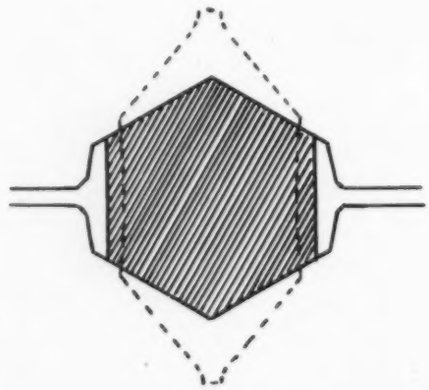
Presented before AISE Annual Spring Conference, Philadelphia, Pennsylvania, May 26, 1947.

*The drawings for this paper were prepared by A. M. Cameron, Roll Designer, Atlas Steels, Ltd.

90° Square.



Leader Groove
Showing Sqr. Entering.



Finishing Groove
Showing Leader Entering.

Figure 3 — The above method is suitable for rolling sizes up to 5/16 in.

3). From $1\frac{3}{16}$ in. up, four passes are generally required, finishing, leader, edging and forming, as shown in Figure 4; or, as an alternative, finishing, leader, round-edge forming and flat pass as shown in Figure 5.

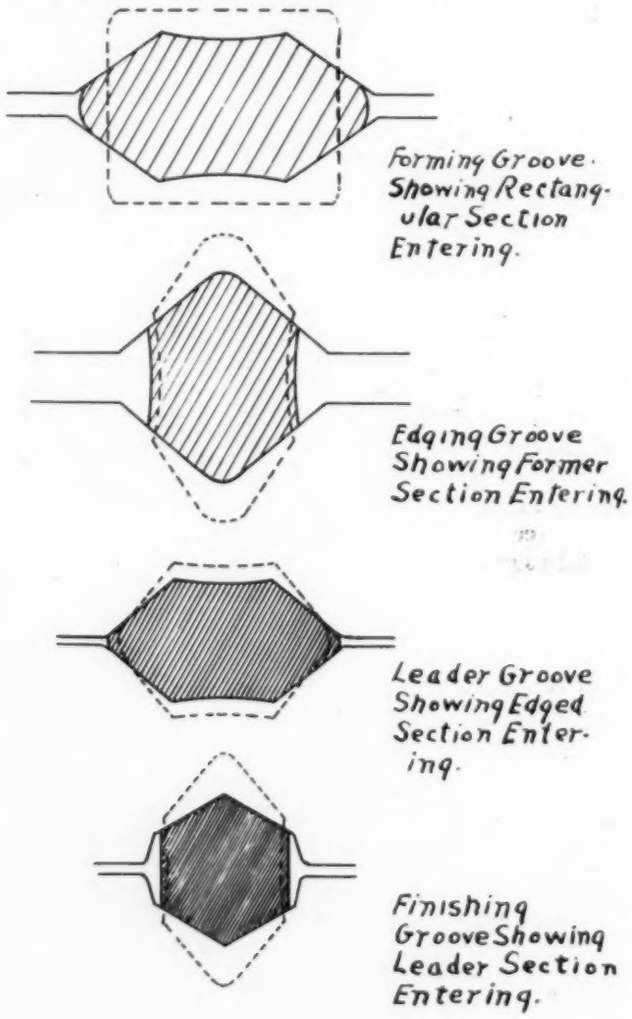
In the second method, finishing with a long diagonal running parallel to the roll axis is commonly called "flat-down" (Figure 6). Producing hexagons by this method, from $\frac{1}{4}$ to $1\frac{3}{16}$ in. also requires the use of two passes, finishing and oval leader, Figure 7, with a 90 degree square being entered into the leader pass. From $1\frac{3}{16}$ in. up, three passes are generally used, the added pass being an edging pass with a reasonable amount of convex and opening. (See Figure 8). To assist in producing sharp corners in the finishing, a leader pass designed with a 140 degree angle is used as shown in Figure 9. As in the former case, a 90 degree square is entered into the leader pass up to $1\frac{3}{16}$ in. From $1\frac{3}{16}$ in. up, the edging pass is again used, with enough stock to fill the apex of the leader groove (Figure 10).

GUIDE ASSEMBLIES FOR THE POINT-DOWN METHOD

Rolls can be designed for this method to permit each pass to be held with flat, entering guides as shown in Figure 11. This type of guide can be used on all sizes. Figure 3 shows a 90 degree square being entered into the leader pass, also the leader entering the finishing groove. Figure 5 shows the square, flat, round-former edging, leader and finishing passes. Figure 4 shows the four-pass method. With any of the three methods, flat entering guides can be used satisfactorily, as there is a minimum of wear on the guides with this method of producing hexagons.

Flat delivery guides are very satisfactory on the forming and leader passes depending on the side-guards

Figure 4 — This method of rolling is adaptable to sizes above 5/16 in.



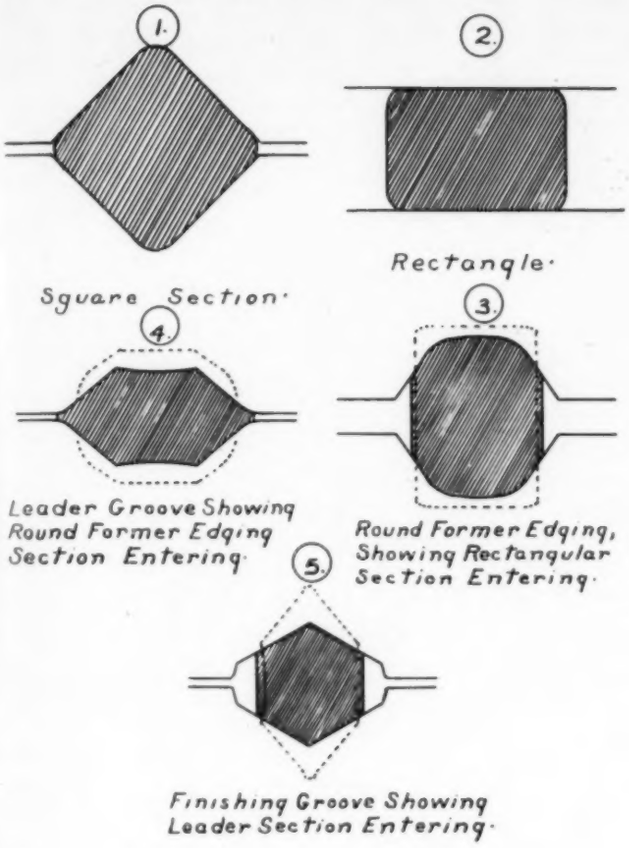


Figure 5 — An alternative method of rolling sizes above 5/16 in. is indicated in the pass series of this figure.

for the side delivery. Less difficulty with scratches is usually encountered with this type of delivery guide. See Figure 12. Shaped guides are also satisfactory and, sometimes, preferred especially on the finishing and edging grooves (Figure 13). All delivery guides should be made of smooth cast-iron material.

ROLLING PROCEDURE FOR THE POINT-DOWN METHOD

In planning to produce a hexagon, using the two-pass shaping method, it is first necessary to determine the size of square to make the required size of hexagon.

Design of grooves, of course, determines the amount of stock to properly fill the width and thickness of the leader pass. Figure 14 shows typical leader and finishing grooves for a half inch hexagon. The finishing pass turned with the 120 degree angle to a reasonable depth, but wider than the finished size and having no collar work,

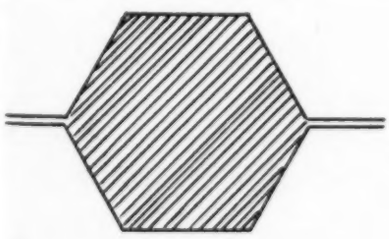


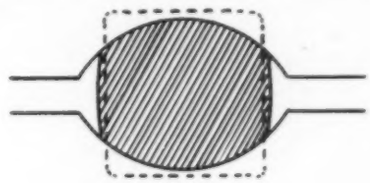
Figure 6 — This sketch shows the design of the finishing groove for the flat-down method.

eliminates any possibility of destroying the corners. In addition to this, one or more sizes can be rolled in the same groove, if desired.

To produce 0.500 in. hexagon in the design shown, the factor of 1.2 x the finished size will determine a satisfactory size square to be used for setting the rolls. (1.2×0.500, or 0.600, would be the size of the square required for 0.500 in. hexagon). Different grades, of course, have to be considered. For example, those which spread more freely automatically require a smaller square.

Every roller has, or should have, some formula to guide him in his decisions on the amount of stock required. The size of the mill also changes the constant in calculating the amount of stock. Figures immediately preceding relate to a 10 in. mill. An 8 in. mill, with the same pass design, would require slightly more stock, and a 12 in. mill would require slightly less. Figure 15 shows a reasonably accurate comparison between the contact area of a bar entering an 8 in. and a 12 in. roll.

After determining the size of square required, it is



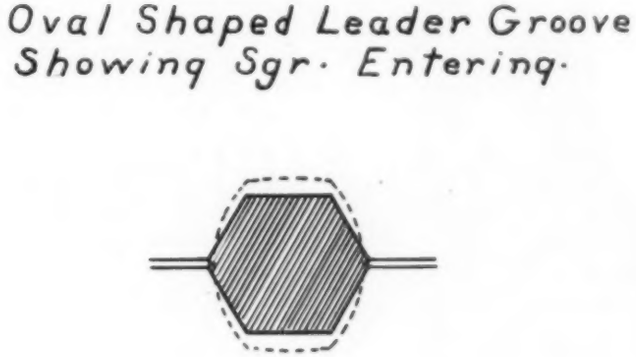
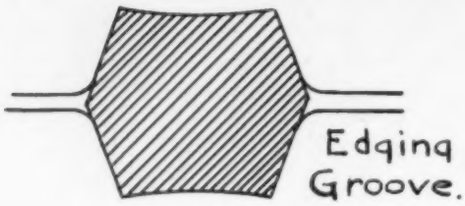
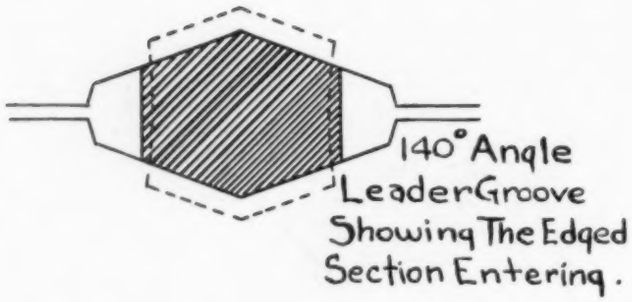


Figure 7 — This method of rolling is adaptable on sizes up to 1 in. if sharp corners are not too essential.

then necessary to adjust the mill so that each groove in the line has the proper amount of stock going into it. The square entering the leader pass must be filled to the point that it will ride straight in the lead groove (Figure 16). The lead groove has to be filled only to the extent that sharp corners will be produced on the top and bottom of the finished bar. The other four corners are made in the leader pass which is the main reason for making sure that the square is riding properly in the leader groove. Adjustments and sizing are accomplished through the use of trial bars which are usually short billets of scrap material.





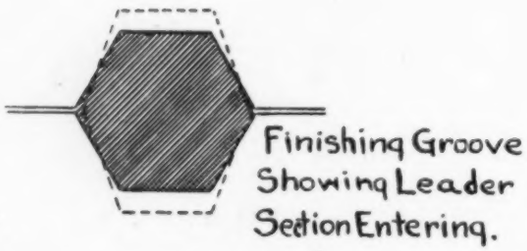
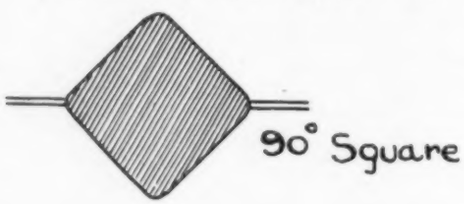
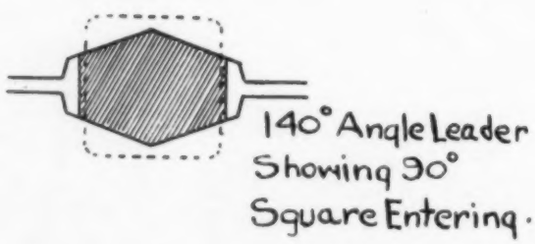


Figure 8 — The method indicated is adaptable to sizes over 1 in. where sharp corners are not too essential.

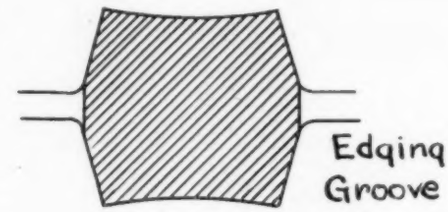
▲

Figure 9 — To produce sharp corners in finishing, a leader pass with a 140 degree angle is used.





To this point, we have assumed that the rolls were plumb. However, should the leader pass be crossed, as shown in Figure 17, with the top roll "in" (the term "in" meaning towards the drive end), the flats on the inside top and the outside bottom of the bar will be wider and out of proportion to the remaining four flat sides. The finished bar will also deliver with a twist towards the outside. This is assuming that bars are running out straight and are not looped. The lead pass is then straightened, by pushing the top roll out or, in other words, towards or with the twist. The flats of the finished bar will then be corrected and the bar will deliver without a twist. When the leader pass is repeated into the finishing pass, the top leader roll would be pushed in to make the correction. Mills using repeaters use an



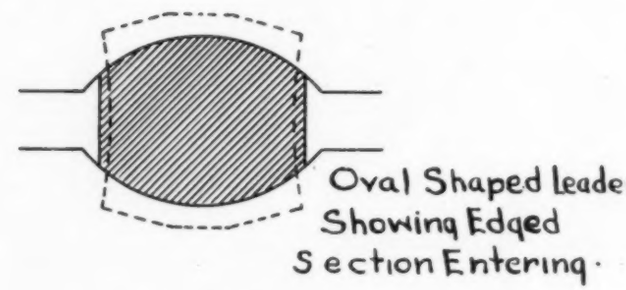


Figure 10 — Above 5/16 in., a pass is used with enough stock to fill the apex of the leader groove.

empty square or an elliptical shaped section as shown in Figure 18. This assists in entering the leader pass and is also easier to control.

If the leader and finishing grooves are both alined perpendicular and horizontal, but the bar delivers with a twist, this will show that the finishing rolls are eccentric (Figure 19). Should a loose chock be used in the outside end of the top finishing roll, it is only necessary to push the roll against the twist, either by wedging between the chock and the face of the housing, or by a special arrangement using a screw instead of a wedge. Even a very slight eccentricity will cause a twist.

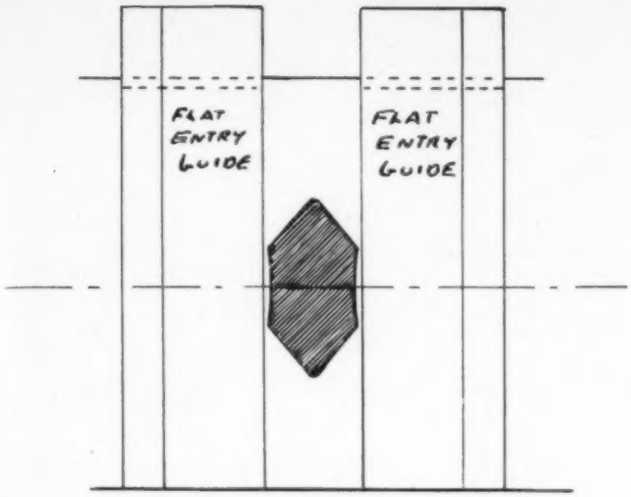
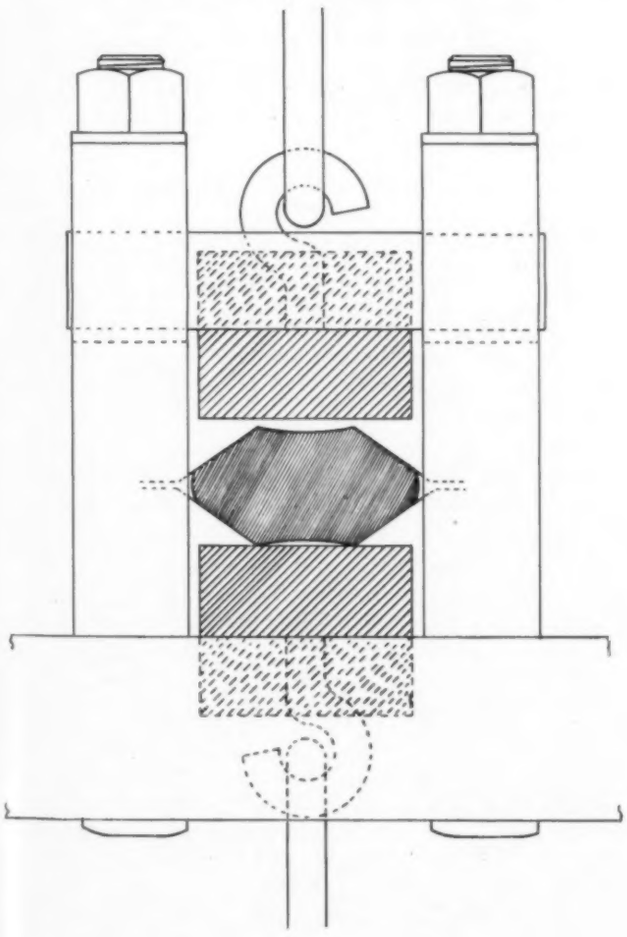


Figure 11 — This is one type of flat entering guide used in rolling hexagons.

In determining the size of the square to produce a 1.000 in. hexagon, when using the method shown in Figure 5, a constant 1.5 x the finished size will give the required square size. Here again it is necessary to consider the effects of spread, roll size and design, which will also be affected by the grade of steel to be rolled.

Figure 12 — Shown here is a delivery guide assembly for hexagon former and leader passes.



After determining the size of square and making sure the opposing diagonals are equal, the square is then reduced in plain rolls to 1⅛ in. thickness and edged into the round-edge forming groove. This will produce a section that rides well in the leader groove. The section delivered from the leader pass is then entered into the finishing groove.

When using the method shown in Figure 4, a larger square is required than the method shown in Figure 5. Using the additional shape forming groove and this type of edging requires more stock. For example, a 1.700 in. square is required to make a 1 in. hexagon, instead of 1.5 in. in the previous method. It is advisable to flat the square before entering into the first former, especially on sizes above 1 in. hexagon. The methods previously described will produce a full section with a clean, smooth surface.

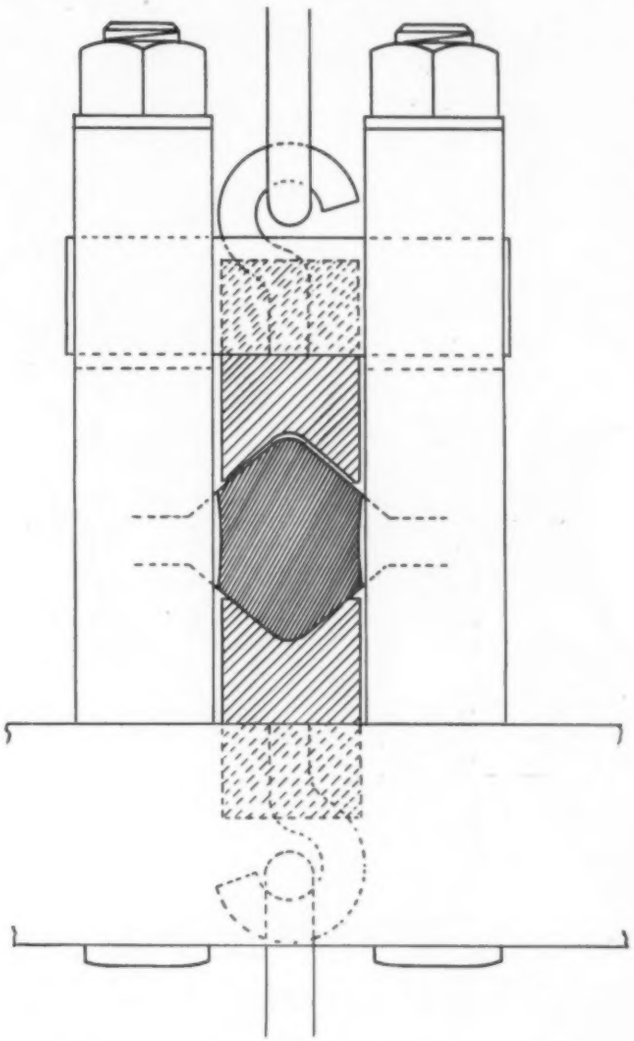


Figure 13 — Delivery guide assembly for hexagon edging and finishing passes.

ROLLING PROCEDURE FOR THE FLAT-DOWN METHOD

Mills producing hexagons to be cold drawn use the

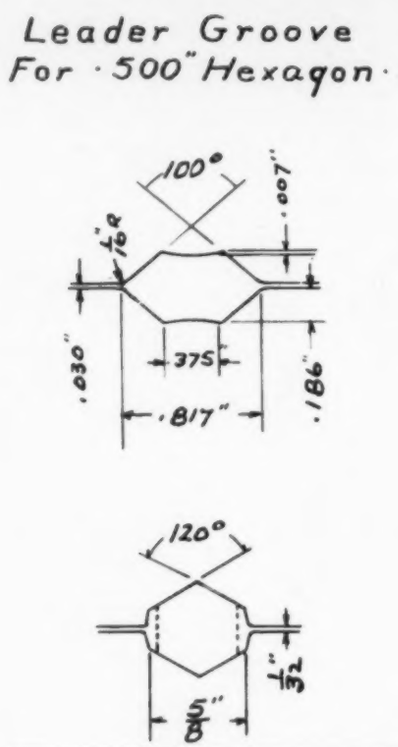
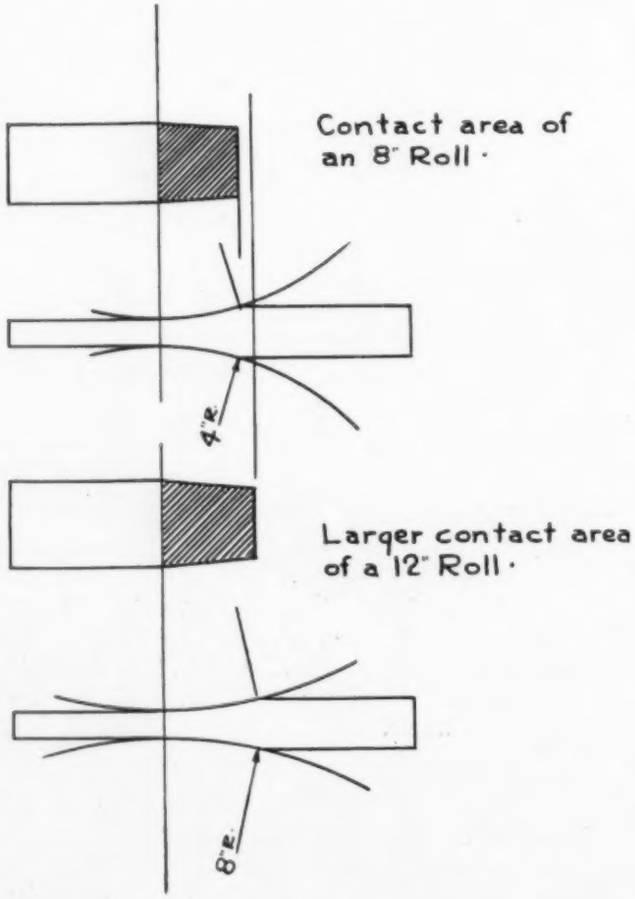


Figure 14 — This finishing groove for 0.500 in. hexagon is wider than the finished section.

method shown in Figure 8, as full corners are not too essential. However, this method will produce reasonably full corners with the finishing rolls running with as

Figure 15 — This sketch illustrates the difference in the contact area of a bar being rolled by two different sized rolls.



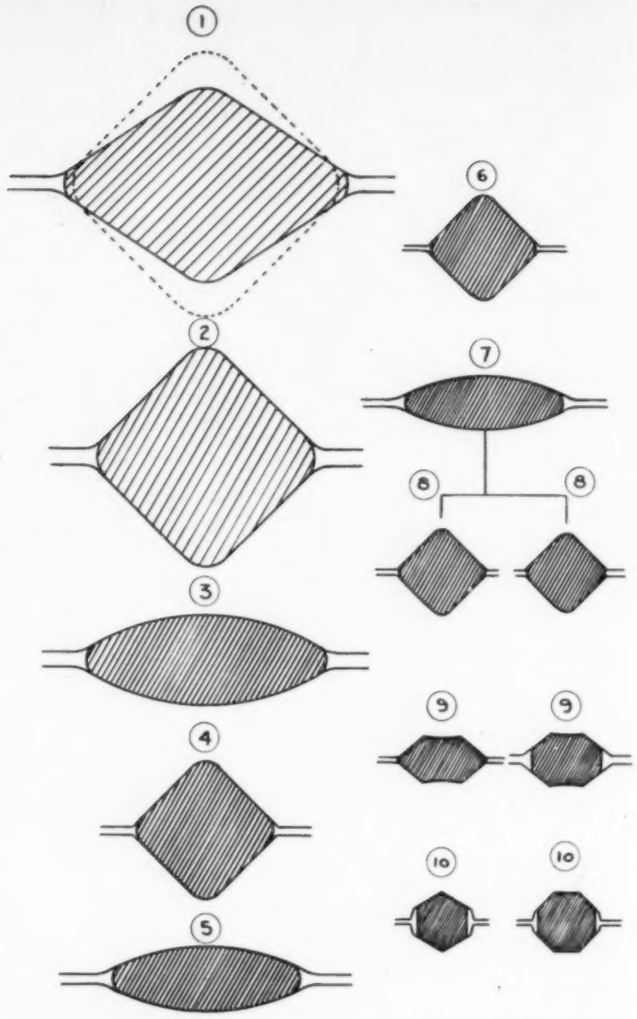


Figure 16 — Shown here is a line of passes for producing hexagons and octagons when starting with a 2⅛ in. square billet.

little clearance as possible. With a long diagonal at the parting of the roll, it is difficult to produce a full corner and not have a slightly overfilled section. The size of square required by this method, to make 1 in. hexagon, is 1.5 in. The procedure is to flat to 1.125 in., enter into the edging groove (which is designed with 15 to 30 degree opening) and then into the ovalshaped leader groove. On small sizes, a 90 degree square can be entered into the oval leader. The leader should be filled so that the edges of the oval are the same width as the flat in the top and bottom of the finishing groove. Should these edges be of less width than the flat in the finishing groove, these four corners will not be filled. With the edges slightly wider at this point, they will produce the corners but will cause the groove to wear rapidly. Figure 9 shows the same method, with the leader designed with a 140 degree angle. The same amount of stock is required with this design as with the oval leader design shown in Figure 7. This type of leader will assist in producing full corners. With either one of the described methods, it is necessary to have a rigid entry guide assembly, as the leader entering the finishing must be held at exactly 90 degrees, otherwise the corners will be destroyed. In addition, flats will not be in proportion

and the bar will deliver with a twist. Should the bar be leaning when entering the finishing pass, it will be necessary to line the entry guides to correct this condition, using the same general procedure as when rolling rounds.

PRODUCTION OF OCTAGONS

Octagons were hammered in the early days for the same reason that hexagons and other sections were hammered. To obtain maximum production from the hammer, the general procedure was to start with a square, practically the same size as the finished octagon, then the corners were worked down and the bar revolved to form each flat as shown in Figure 20. Exceptional skill was required in forging to produce a section with proper diameter dimensions and all eight sides of equal width. Quantities that do not warrant a rolling setup are still hammered today; also, large octagons are hammered and machined to rounds on some tool steel grades.

The rolling procedure for an octagon is approximately the same as for a round. Considering that this section has corners and flat surfaces, it would seem a reasonable assumption that it would be less difficult to roll than the round section, but this is not the case. Diameter dimensions can be fairly uniform and yet, at the same time, the eight flat surfaces may be unequal and the corners improperly filled.

In producing an octagon, special care must be exercised in the following operations: rolls must be kept properly alined on the lead passes, finishing entry guide assembly should be set up accurately, and guide manipulation requires the same close attention during rolling as is the case when producing a round.

The finishing guide assembly is important and should be as rigid as with guide rounds. Guide assembly should be set up with the same precision methods as with guide rounds, using a gear-type box, shown in Figure 21, with the shaped entry guides having the same shape as the leader pass or, if roller guides are used, they also are shaped to fit the leader pass and are used in a solid type

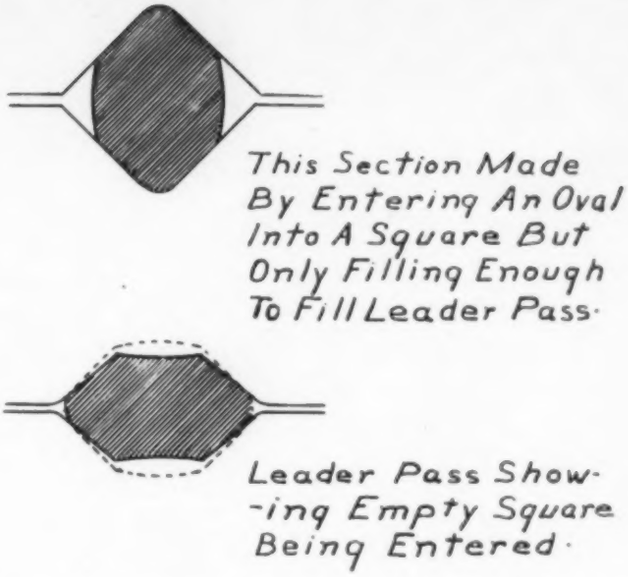

This Section Made By Entering An Oval Into A Square But Only Filling Enough To Fill Leader Pass.
Leader Pass Showing Empty Square Being Entered.

Figure 18 — The section shown helps in entering the leader pass and is relatively easy to control.

Figure 17 — If the rolls are slightly crossed, two of the flats on the hexagon will be out of proportion to the other four flat sides.

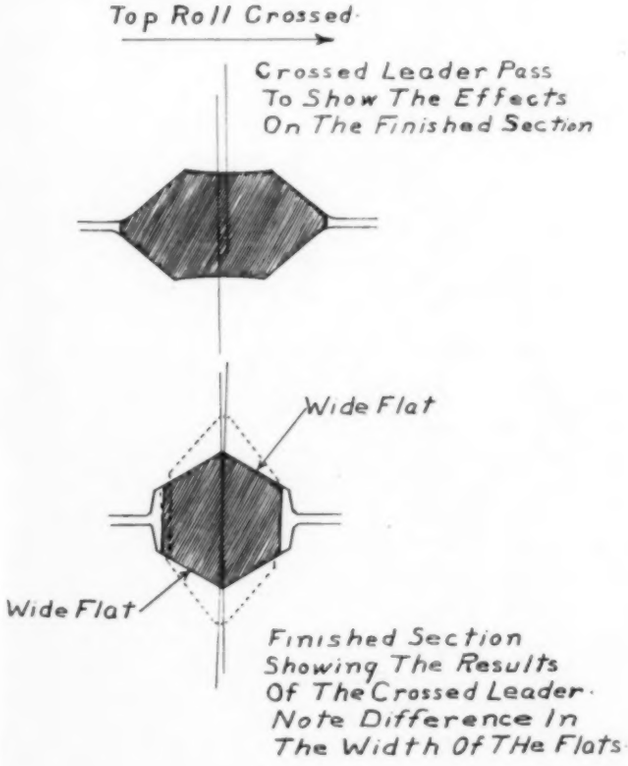
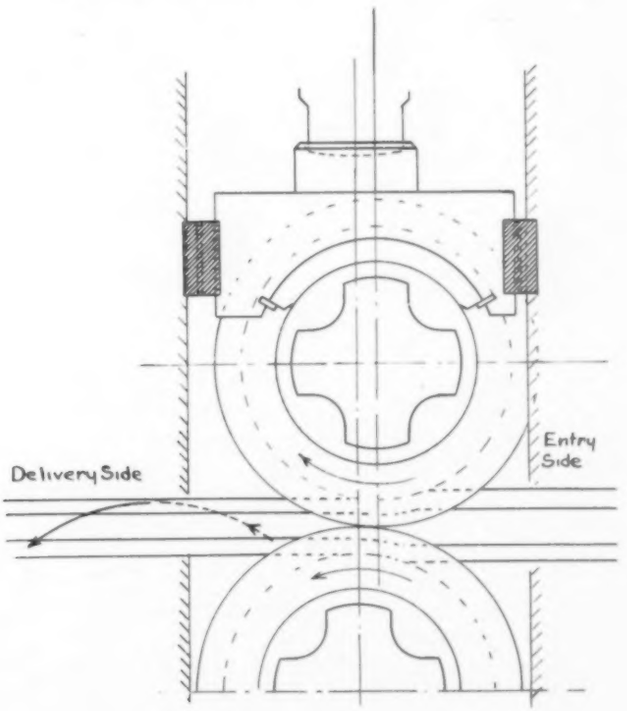

Top Roll Crossed
Crossed Leader Pass To Show The Effects On The Finished Section
Wide Flat
Wide Flat
Finished Section Showing The Results Of The Crossed Leader. Note Difference In The Width Of THe Flats

Figure 19 — This sketch shows the finished bar twisted out when the outside end of the top roll is off center towards the entry side. To eliminate the twist, the top roll must be moved towards the delivery side, or against the twist.



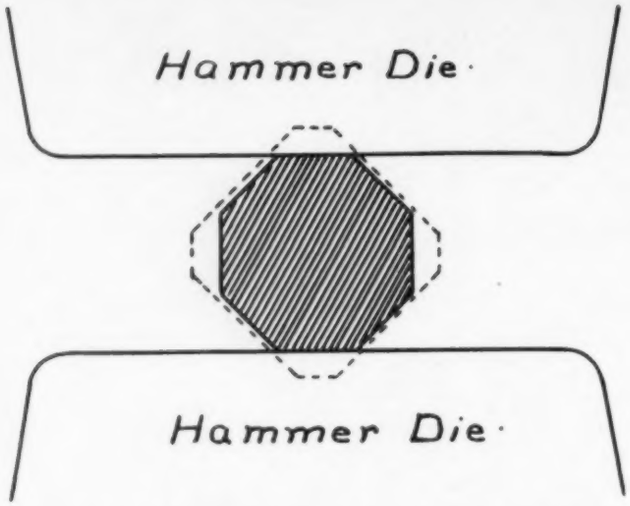


Figure 20 — Original octagon sections were forged from a square billet slightly larger than the finished bar.

box (Figure 22). Guides should be made of chilled iron, or special alloy material, with the grooves ground to a set bar in pairs and the base also ground square, so that they are in perfect alinement as shown in Figure 23.

stock required to produce the octagon (Figure 16).

The sizing is done by the use of trial bars usually short billets of scrap material. Where a number of grades are made, the roller has to estimate, from the results of the trial bar, the adjustments to make for the first bar of regular stock. After this is accomplished, the finishing entry is then the point that requires careful attention and adjustments, at intervals, to produce a uniform octagon. At this point, we assume that all other precautions have been taken. Each pass must be filled with the right amount of stock to assist in holding the bar without depending entirely on the entry guides to do the work.

Leader grooves for octagons are usually turned wider than the section being delivered from it (Figure 25). This groove should be filled so that the sides, or edges, of the leader will be the same width as the flat in the top and bottom of the finishing pass. This is very important. If the edges are too narrow, the corners will not fill, also the section will be difficult to hold in the entry guides and this, naturally, will cause excessive guide wear.

The square entering the leader pass must have exact, opposing diagonal dimensions to prevent the square from leaning (Figure 26) which causes the edges of the

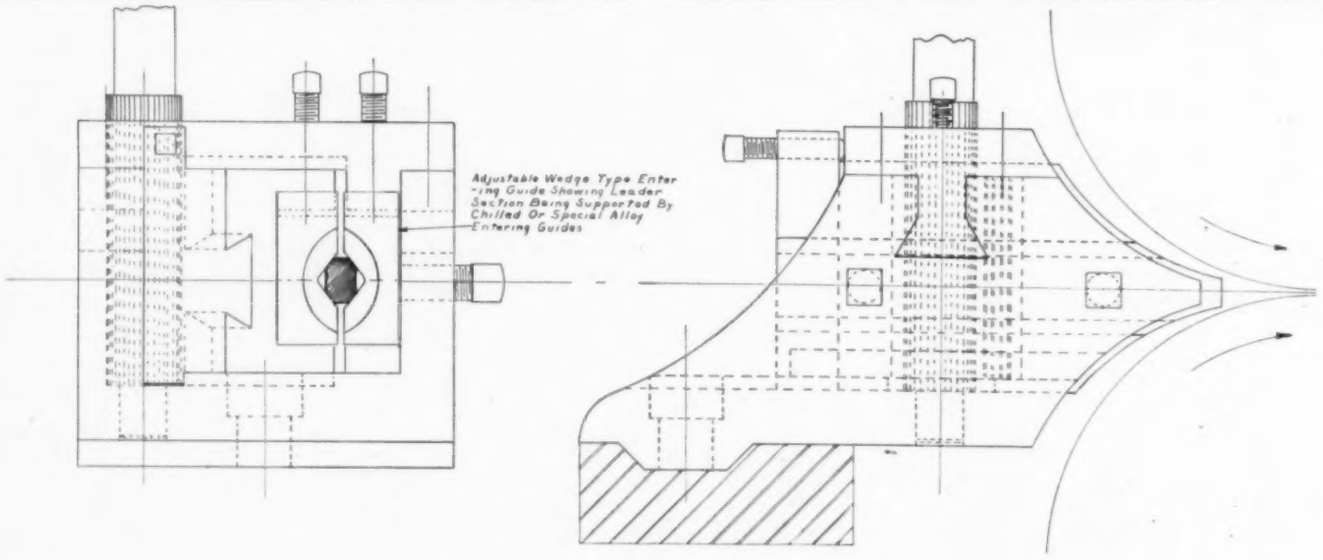

Adjustable Wedge Type Entering Guide Showing Leader Section Being Supported By Chilled Or Special Alloy Entering Guides

Figure 21 — Adjustable wedge type guide box.

ROLLING PROCEDURE FOR OCTAGONS

Octagons, in sizes ranging from 1/4 to 13/16 in. can be made in two shape passes, leader and finishing. A square is used when entering into the leader pass. See Figure 24. In planning to produce an octagon in this range, there are certain, definite steps that must be followed to determine the production procedure. The decisions that must be made are:

1. The size of the square necessary to make the octagon. Using the constant, 1.100 x the finished size, will give the satisfactory size of square to set the rolls.
2. The correct distribution of draught throughout the train of rolls down to the proper amount of

leader to be beveled. This section then, when entering the finishing groove, will cause unfilled corners and the flats of the octagon will be uneven. After obtaining the proper section from the leader pass, let us assume that the rolls are in perfect alinement and consider that the finished octagon has a shoulder on the inside with the bar twisting in the same direction, and the leader section leaning in the same direction in the entry guides. Figure 27 will show that this condition causes the section to have irregular flat surfaces.

We will assume, at this point, the leader is alined properly, and the bar being delivered from the leader is of the dimensions required. After this is determined, we then know that the cause of the off-section is in one of two places. The first step for correction is to insert a

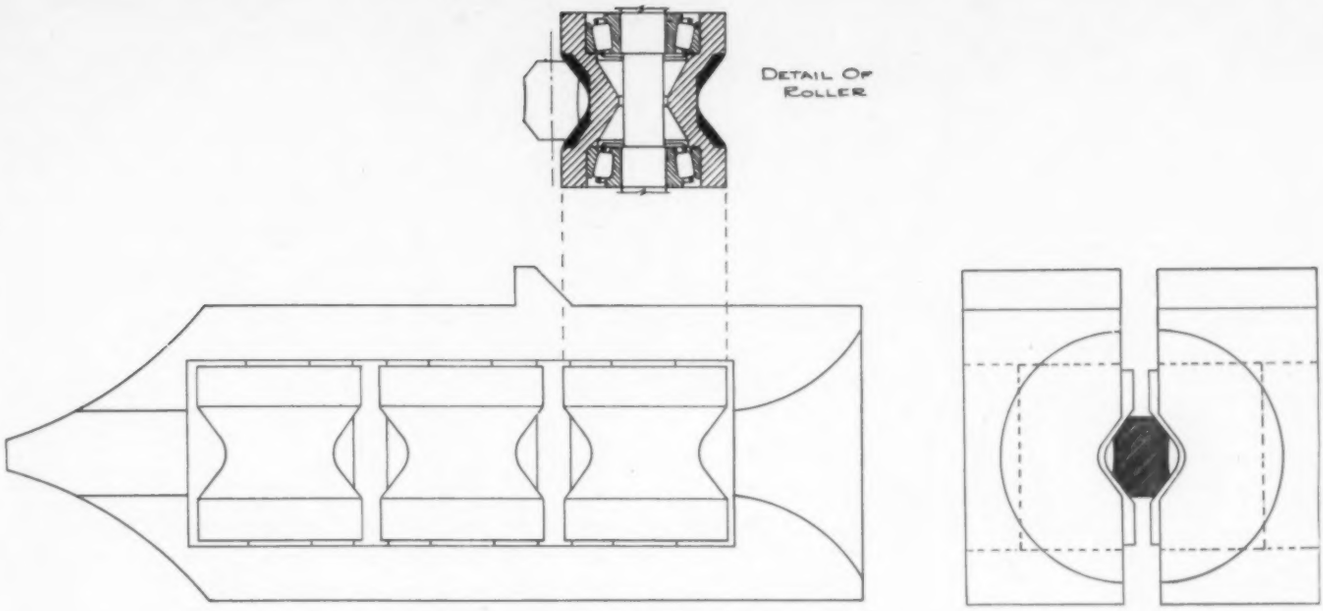


Figure 22 — Roller guide assembly for octagons.

liner under the outside entry guide as in Figure 27, to hold the section to exactly 90 degrees when entering the finishing groove. The next step is to make certain that the rolls are not eccentric. Should the top roll, on the outside end, be off-center towards the delivery side, a pull will be exerted forcing the leader section to lean towards the inside, which eventually will wear the guide and thus make it necessary to insert another liner under the guide.

Should the condition described be in the opposite direction, the corrections would also be made opposite to the corrections previously outlined.

Another condition to consider is a shoulder on the inside top with the section twisting towards the outside. The finished bar then will have unequal, flat surfaces on the shoulders as in Figure 28. The top inside shoulder, and bottom outside shoulder will be narrow. The top outside shoulder, and the bottom inside shoulder will be wide. This condition can be corrected by pushing the top finishing roll towards the outside which will eliminate the twist, equal the shoulder dimensions and equalize the flat surfaces.

Another condition is to have a shoulder on the outside with the section twisting towards the outside. Assuming we have made certain that all of the previous conditions have been corrected, such as finishing roll alinement and section entering the finishing groove being held in correct position, we now find that the leader rolls are crossed with the top roll towards the inside (Figure 29). To correct this condition it is necessary to push the leader towards the outside. This will eliminate the twist and the shoulder.

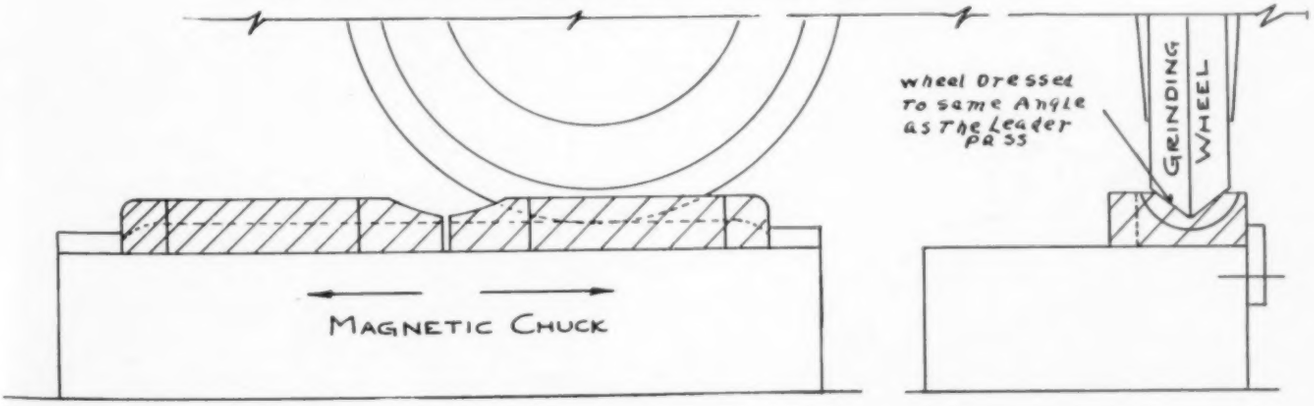
To this point, we have described the conditions that arise in producing the finished octagon by entering a square into the leader which covers the range from ¼ to ¾ in. inclusive.

On sizes above ¾ in., the better method is to use four passes as shown in Figure 30, finishing, leader, edging groove and flat. The edging groove is designed and turned with sharp corners and sufficient convex in the roll to deliver a section from the leader with a slight concave on the edges of the section.

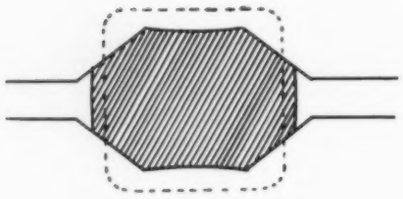
The constant that can be used for determining the size of the square is 1.300 x the finished section required. Other factors that should be considered, when using this constant, are design of the grooves, grade of steel, and size of mill.

Having obtained the proper size square with exact opposing diagonals (to make 1 in. octagon), it is then entered into a flat pass and the section is reduced to a

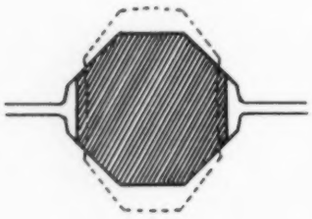
Figure 23 — Guides are ground in pairs to assure perfect alinement.



90° Square.



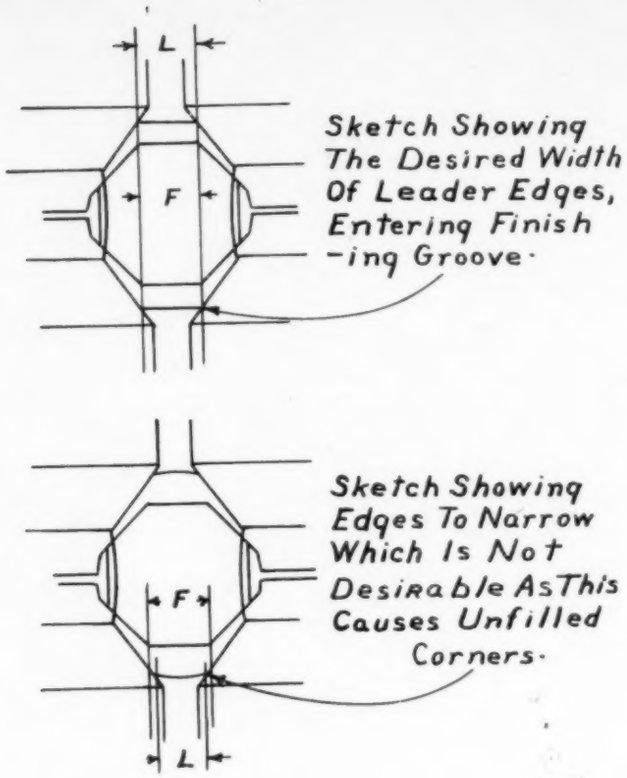
Octagon Leader Pass Showing Square Entering.



Octagon Finishing Pass Showing Leader Section Entering.

Figure 24 — Octagons up to 5/8 in. can be made in two shaped passes.

thickness of $1\frac{3}{32}$ in. and is then entered into the edging pass. The section delivered from the edging pass must be filled to the extent that the flat surface will be equal to the width of the flat in the top and bottom of the leader (Figure 31). This factor is important since, with this part of the section too narrow or too wide, the corners will be unfilled. To change the width of the flat part of the section being delivered from the edging pass, it is only necessary to increase, or decrease, the amount of stock. If the flat surface is too wide, we increase the size of the square or thickness of the flat. If the flat surface is too narrow, we decrease either the size of square or thickness of flat. While making a change of the stock, at this point, it is also necessary to consider that an increase, or decrease, of stock will affect the leader pass and the height of the edging up or down should be adjusted to maintain the proper width bar being delivered from the leader. Here again it is necessary to consider the design of grooves, size of mill and grades that may cause different spread of the material during rolling.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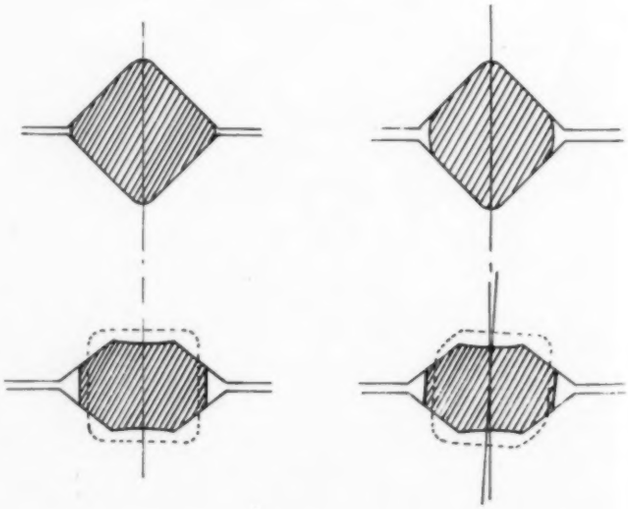
F
Sketch Showing The Desired Width Of Leader Edges, Entering Finish -ing Groove.
F
Sketch Showing Edges To Narrow Which Is Not Desirable As This Causes Unfilled Corners.
L

Figure 25 — Desirable width of leader grooves is wider than that of the section that emerges from the leader.

FINISHING GROOVES FOR HEXAGONS AND OCTAGONS

It has been considered generally that the finishing grooves are wider than the finished size, with the exception of finishing hexagons with flats down. On both

Figure 26 — Left side of this sketch shows how a square with equal diagonals will ride straight in the leader, whereas on the right is illustrated how a square with unequal diagonals gives beveled edges.



sections, the main advantage is the elimination of destroyed corners due to the section entering and rubbing the collars (Figure 32). This open design does aid in maintaining the corners; however, care is necessary to produce equal flats. These can be controlled by the procedure described earlier in this paper.

Hexagons can be made by having the 120 degree angle turned in each roll (Figure 33). The reason for designing the grooves wide with collars between is to conserve space, assist in alining the grooves and to run the rolls nearer the center line of the mill. It is feasible to finish more than one size of hexagon but of one groove on small lots where the tonnage is not great enough to wear the groove.

It is necessary to have a special groove for each size of octagon due to this section having eight flats and corners. If a 1.000 in. octagon is required, the finishing groove must be turned as shown in Figure 34, with flat dimension being 0.414 in. If 1.020 in. octagon is required, a special groove must be turned as in Figure 35 with the flat equaling 0.422 in.

The method of using open, finishing grooves causes the roller less difficulty in producing sharp corners, but does not lessen the difficulty of producing equal flats. However, should the flats be slightly irregular, the appearances of the octagon or hexagon is still superior to the section with destroyed corners.

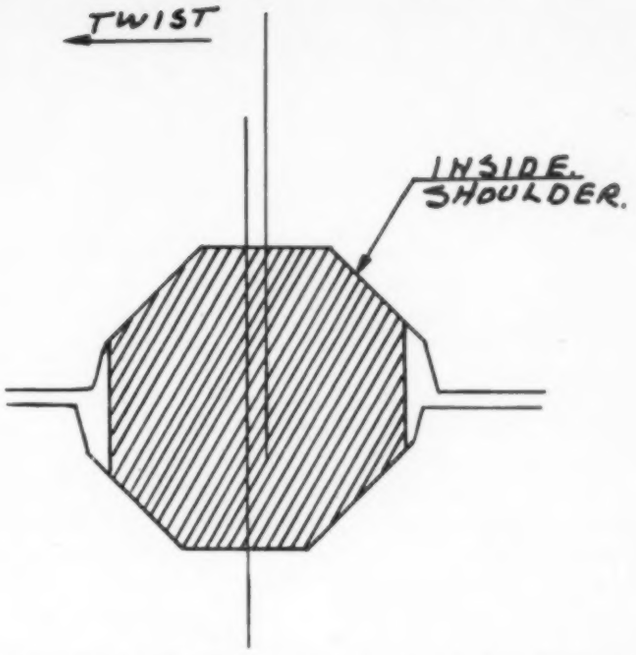
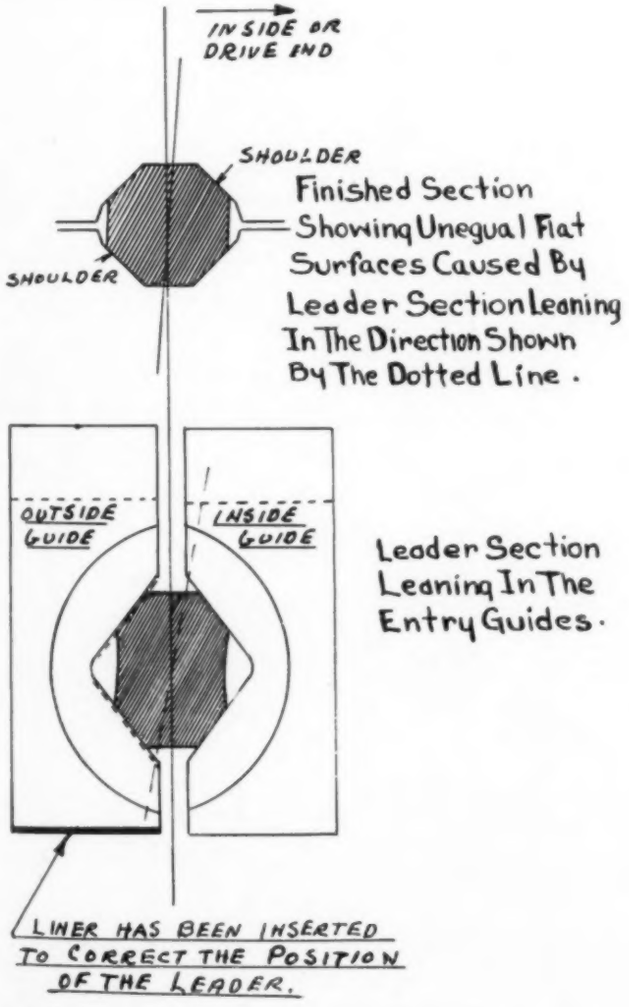


Figure 28 — This sketch shows the unequal flat surfaces and the high and low shoulders which result when the finishing rolls are crossed.

Figure 27 — A liner under the guide position may be all that is required to insure that the leader section is of uniform size.


INSIDE OR DRIVE END
SHOULDER
SHOULDER
Finished Section Showing Unequal Flat Surfaces Caused By Leader Section Leaning In The Direction Shown By The Dotted Line.
OUTSIDE GUIDE
INSIDE GUIDE
Leader Section Leaning In The Entry Guides.
LINER HAS BEEN INSERTED TO CORRECT THE POSITION OF THE LEADER.

THE ROLLING ORGANIZATION

Producing different sections involves similar rolling principles, but each section has peculiarities requiring a different approach by the roll designer and the roller.

With symmetrical sections such as rounds, hexagons,

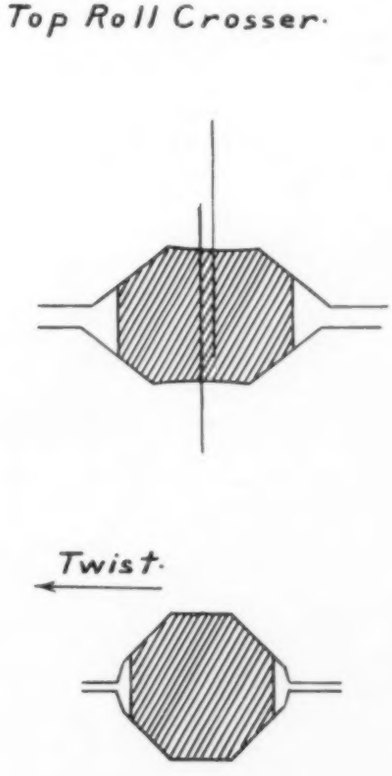


Figure 29 — This figure shows the unequal flats and the direction of twist when the leader rolls are crossed toward the inside of the mill.

octagons and squares, the rolls are designed and turned, and the roller then proceeds to produce the required section, applying his experience and rolling technique. His aim is to produce the section in a minimum of time. After setting the mill, and assuming that guide assemblies and rolls are set properly, he proceeds to obtain the section in accordance with size and surface specifications.

Let us assume the section and size has been obtained but close inspection indicates that the surface is not according to specifications. The roller will then inspect each pass to determine if it is too full, or too empty, and make suitable adjustment as nearly correct as possible. He then makes sure that the billet coming from the furnace is heated in accordance with heat specifications for that particular grade. On second inspection, the surface may still show imperfections but is passable and, at this point, the roller believes that the mill conditions are right, that each groove is filled properly and that the application of water on each groove is satisfactory. A resourceful roller will produce the order but will contact the roll designer, or his assistant, and plan changes for the next rolling. Improving the surface may require a slight change in design in one or more grooves, a change in roll hardness, etc.

Should the roller be unsuccessful in obtaining the section, the roll designer, or assistant, should be contacted before the rolls are removed from the mill and samples should be taken from each groove so that the roll designer can obtain information to assist in making the necessary changes.

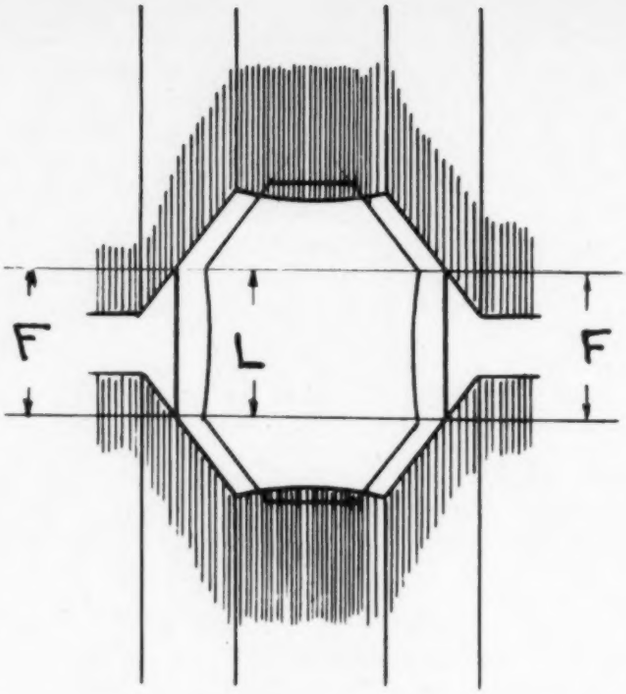


Figure 31 — This schematic sketch shows the leader and former section, and how the width of the flat surface of the former section matches the leader groove.

Experience has indicated that rolling mill efficiency has been materially influenced through the proper delegation and distribution of responsibility to the mill personnel. For example, there is the case of a mill operating more than one turn. It is logical, and has been proven effective through practice, to have a head roller in charge of one turn, who is also responsible for the performance of all turns on that particular mill. Vesting responsibility clearly on the shoulders of one individual is not only sound, from an organization standpoint, but,

Figure 30 — Typical design for rolling a 1 in. octagon section.

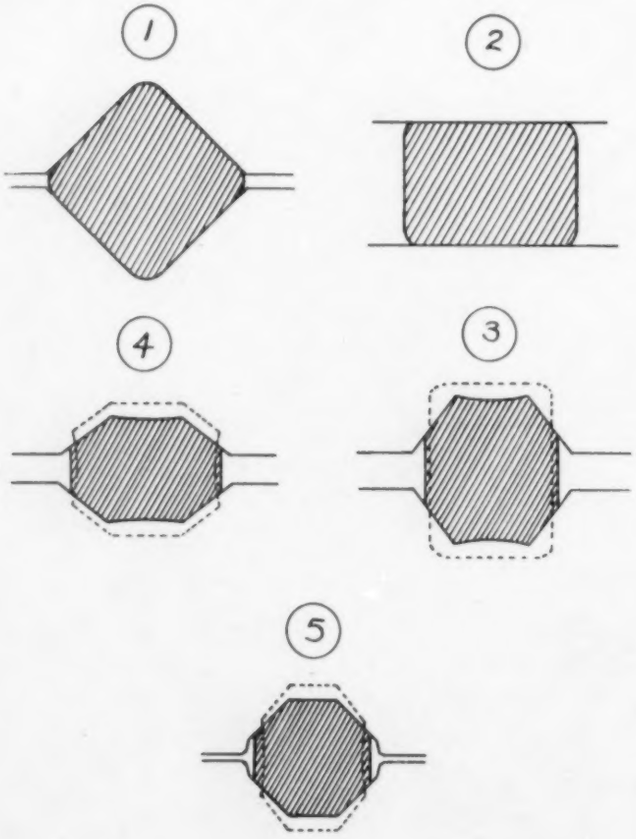
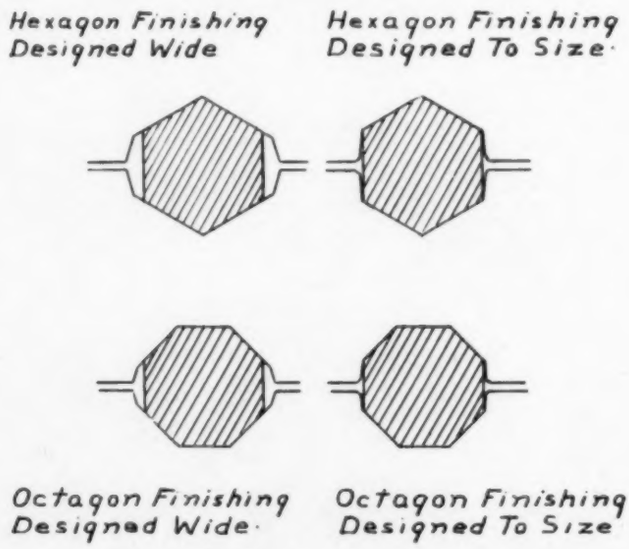


Figure 32—The open design aids in maintaining corners.


Hexagon Finishing Designed Wide
Hexagon Finishing Designed To Size
Octagon Finishing Designed Wide
Octagon Finishing Designed To Size

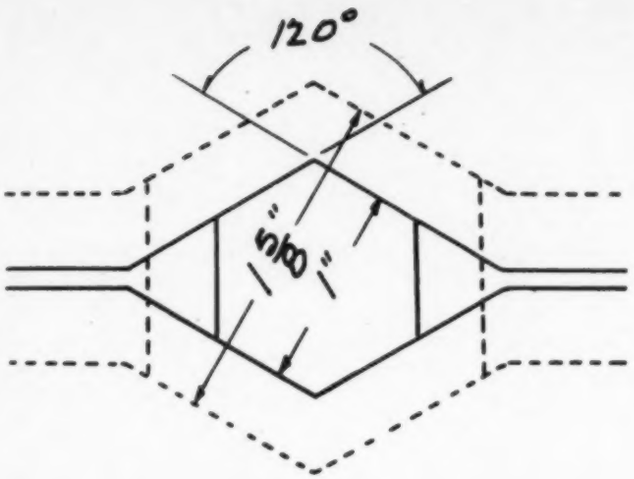


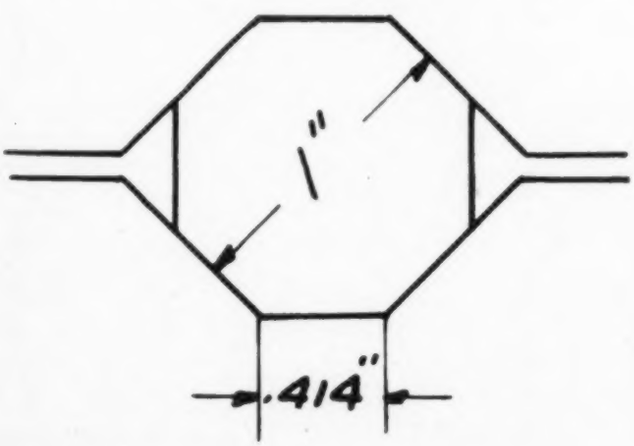
Figure 33 — Design of hexagon finishing groove with a 120 degree angle. The dotted line shows the limit of size that can be produced.

as an illustration of the advantages in this particular case, we cite the following factors, each of which contributes substantially to successful operations.

1. Correct rolling procedures and techniques are standardized and used on all turns.
2. Experience and knowledge of a skilled roll designer is most effectively applied through close liaison and cooperation with a head roller.
3. Lower costs are entailed in the design and makeup of roll and guide assemblies since the designer does not have to satisfy several parties, all of whom may have a different approach to the same problem in endeavoring to arrive at the same result.
4. Refinement and improvements developed, on any turn, are readily adopted by the other turns which may accomplish increased output or improved quality.

In this section, referring to organization, it is not the intention to infer that the advantages can only be realized through the type of organization indicated. However, sound organization generally makes such a vital contribution to performance that it was considered

Figure 34 — Finishing groove for 1.000 in. octagon.



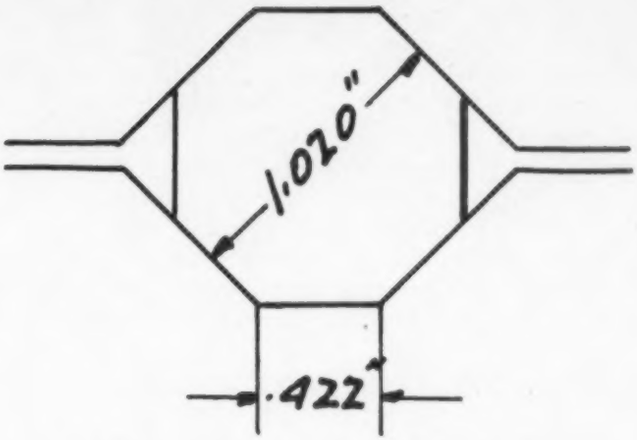


Figure 35 — Finishing groove for 1.020 in. octagon.

worthwhile to refer to one plan of organization that has proven successful.

Rolling procedures and principles which are fundamental will continue to be applied regardless of modernization of mills and auxiliary equipment. With modern design mills equipped with bearings and guides that produce little or no wear, also with roll designers as they are today striving to improve quality and production, the roller is being assisted in producing greater tonnage and improved quality that twenty years ago would have seemed impossible. We have no reason to believe that the same progress will not be accomplished in the years to come.

DISCUSSION

PRESENTED BY

ROSS E. BEYNON, Superintendent, Roll Shop, Carnegie-Illinois Steel Corporation, South Works Chicago, Illinois

C. P. HAMMOND, Superintendent Rolling Mills, Atlas Steels Limited, Welland, Canada

S. D. GLADDING, Superintendent of Saucon Division, Bethlehem Steel Company, Bethlehem, Pennsylvania

S. C. READ, Manager, Maintenance, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

Ross E. Beynon: Do you find it more difficult to secure sharp corners on the hexagons and octagons when rolling from alloys or high-speed steels, than from open hearth steels?

C. P. Hammond: Straight carbon steels require more stock than most of the highly alloyed grades to produce sharp corners. This is based on the rolls being used, designed to roll the alloy grades.

S. D. Gladding: I would like to ask what is the largest hexagon that you roll, Mr. Hammond?

C. P. Hammond: Our largest sizes of hexagon is 3⅛ in. diameter and the largest octagon is 3¼ in. All passes are open as described previously. With hexagon, we use

a round former pass, making an elliptical section to enter the hexagon leader. This former or edging pass also cleans the bar. On the octagon, we use a quarter octagon former as described previously. The hexagon leader can be supported with flat guides when entering the finishing pass. The octagon requires shaped guides.

S. C. Read: May I ask two questions: one is, have you found it any more difficult in rolling high sulphur steels, to get a good corner? We have observed that if we do not have a good section in the leader, there is very small chance of getting a good corner in the finished product.

The other question I have is, we are studying the rolling of a 3 in. or 2⅞ in. hexagon on a cross-country mill. Can we get a sharp corner on this size or do we have to be content with a certain radius at the corners?

C. P. Hammond: High sulphur, carbon steel flows about the same as the regular straight carbon grades. If you turn the finishing groove open, using the "point-down" method and a proper design of leader plus former passes, you will have very little difficulty with the corners. The same principle will apply on the rolling of 2⅞ and 3 in. hexagon, with enough stock the corners should be comparable to the small sections.

Member: As to some of the difficulty in twisting that is encountered in connection with the spindles and boxes as far as the sections are concerned, we roll only the octagon; but we do experience a lot of trouble in the twisting. I would like you to comment on that.

C. P. Hammond: I believe you run into more difficulty with twist using the flat-down method. At least, that has always been my experience. I have had only one experience rolling hexagons, using the flat-down method, and consider it less advantageous in obtaining sharp corners, but less difficult to obtain uniform width of flats on the hexagon section. With the point-down method, using a wider flat surface on the leader with enough convex to bring it back to shape, it is easy to control. All that is required is a pair of flat guides to support it. The only time that you can get in trouble with your spindles is that you might have one that is a little long, or might have a worn box and, if the spindle is pushing against the finishing roll, you are in trouble until you change it. Spindles can definitely cause twist and also eccentricity. That is one of the things that a roller, who has not been rolling hexagons or octagons in any quantity, will have to think about, whether his finishing rolls are right in line or not; or in other words, whether they are over one another. One way to find that out is by the use of a plumb bob or a parallel bar which is satisfactory in determining if your rolls are over one another or not. It requires very little eccentricity of the rolls to cause your hexagon or octagon to twist, and it takes very little cross in your leader to cause the section to twist.

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INDUSTRIAL USES OF SOME

Polyether Synthetic Lubricants

By W. H. MILLETT
Carbide and Carbon Chemicals Corporation
Tonawanda, New York

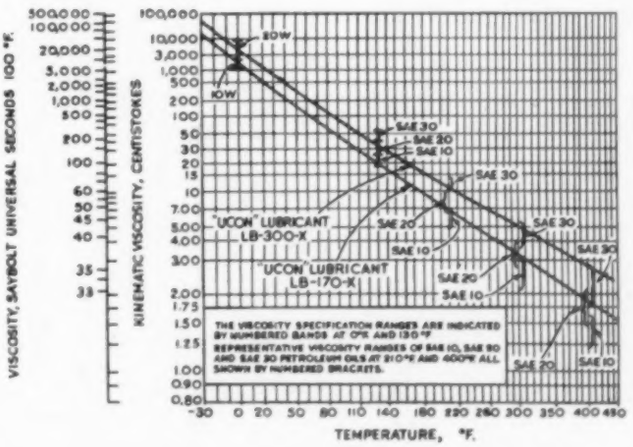
. . . . although synthetic lubricants may be initially relatively expensive at the present, superior performance during operation may more than justify their use . . . .

▲ IN recent years there has been a widespread interest in the commercial availability and utilization of various types of synthetic oils and lubricants. These synthetic products may be roughly classified into two distinct groups. One group is composed of synthetic hydrocarbons. These materials are similar in chemical structure and physical properties to the conventional petroleum oils with which we are all familiar. The second group is composed of non-hydrocarbon synthetics. Because of their different chemical constitution, these synthetics will be expected to differ markedly in many respects from mineral oil products, vegetable and animal oils and fats. The term "synthetic" in chemical language refers to products which are built up from the elements or from smaller molecules and as used herein does not imply that the products are substitutes or "ersatz" materials. The possibility of utilizing their unusual properties in solving various industrial lubrication problems is worthy of consideration.

One of the commercially available, non-hydrocarbon synthetics is the family of synthetic lubricants marketed under the brand name "Ucon"* (1-5)†. These materials are members of the family of chemical compounds known as polyalkylene glycols and derivatives and may be described by the general term, polyethers. At the present time three series are being manufactured in commercial quantities; namely, the "LB", "50-HB", and "75-H" series. In the nomenclature of these synthetics, the number which follows the type classification represents the approximate Saybolt Second viscosity at 100 F. An "X" following the viscosity in the code name indicates the presence of a standardized oxidation inhibitor and is recommended in cases where improved oxidation stability is desired. The letter "Y" in the symbol indicates the use of an additive, other than the standardized antioxidant, to impart improved extreme pressure characteristics, "oiliness" properties, etc.

These fluids are polymeric materials and can be made to any desired viscosity within the particular limitations of the reaction involved. Whereas, conventional petroleum lubricants are mutually insoluble with water, the "LB" series is characterized by water tolerances of the order of 1 to 3 per cent, and the "50-HB" and "75-H" series are characterized by water miscibility at ordinary temperatures. Viscosity indices of the synthetics are higher than those of non-additive mineral oils, and in general, their stable pour points are considerably lower. They also differ from conventional lubricants in that there is no marked tendency for their oxidation products to form insoluble sludges and that they tend to burn-off practically completely from metal surfaces when maintained at elevated temperatures. Because of these different and interesting properties, it will be worthwhile to consider them and their application in more detail.

Figure 1 — Viscosity-temperature chart of polyether synthetic lubricants LB-170-X and LB-300-X.


VISCOSITY, SAYBOLT UNIVERSAL SECONDS 100 °F.
KINEMATIC VISCOSITY, CENTISTOKES
TEMPERATURE, °F.
"UCON" LUBRICANT LB-300-X
"UCON" LUBRICANT LB-170-X
20W
10W
SAE 30
SAE 20
SAE 10
THE VISCOSITY SPECIFICATION RANGES ARE INDICATED BY NUMBERED BANDS AT 0°F. AND 130°F.
REPRESENTATIVE VISCOSITY RANGES OF SAE 10, SAE 20, AND SAE 30 PETROLEUM OILS AT 210°F. AND 400°F. ALL SHOWN BY NUMBERED BRACKETS.

Presented before AISE Annual Convention, Pittsburgh, Pennsylvania, September 24, 1947

*Trade Mark, Carbide and Carbon Chemicals Corporation.
†Numbers refer to bibliography at end of paper.

PROPERTIES OF THE LUBRICANTS

The physical and chemical properties of various members of each series of these synthetic lubricants are tabulated in Table I-IV. Inspection of these tables will reveal the following general properties:

1. Viscosity-temperature characteristics of the lubricants are very favorable. Viscosity indices, in general, range from 135 to 155 depending on the type and viscosity of the product. Although this is outside the range for which the concept of viscosity index was originally established, it is the most convenient and generally utilized means of referring to the viscosity-temperature properties of a lubricant. Because of the high viscosity indices, classification of the lubricants according to standard SAE grades is not feasible since these liquids will correspond to different grades at different temperatures. This is readily illustrated by the viscosity-temperature chart shown in Figure 1. The high viscosity indices are not attained through the use of additives but are inherent properties of the fluids themselves.

2. The pour points of these lubricants are considerably lower than would be expected of mineral oils of comparable viscosities. There are no pour point depressants in these synthetics, and since they contain no wax, pour points are completely reproducible when determined by the cyclic ASTM method or similar procedures.

3. Flash points are comparable to or slightly higher than those of mineral oils of comparable viscosities.

4. Specific gravities of these synthetic lubricants are high and range from 0.98 to 1.09 at 60 F depending on the type and viscosity of the product, as compared with values ranging from 0.86 to 0.92 for petroleum oils.

There are several other properties which render these synthetics of interest and which distinguish them from oils in conventional use. The following inherent characteristics are particularly noteworthy:

1. Non-sludging characteristics—The principal oxidation products of these synthetic lubricants are either volatile compounds of low molecular weight or compounds having similar properties to those of the original fluid. Because of this, the formation of insoluble sludges is minimized provided systems are adequately ventilated. This is particularly noticeable after prolonged operation. Under these conditions, mineral oil oxidation products may polymerize and form insoluble sludges which frequently interfere with the effective operation of the lubricated mechanism.

TABLE I

Typical Properties of Standard Grades of LB Series Lubricants

Standard Grade	LB-135	LB-165	LB-285	LB-385	LB-525	LB-625	LB-1145
Viscosity							
Saybolt seconds at 210 F	45.1	48.6	62.7	75.1	93.1	106	177
Saybolt seconds at 100 F	135	165	285	385	525	625	1,145
Saybolt seconds at 0 F	4,700	6,400	14,200	21,600	33,000	41,000	92,000
Centistokes at 210 F	5.77	6.85	11.0	14.3	18.8	21.9	37.8
Centistokes at 100 F	28.7	35.4	61.7	83.3	114	135	248
Centistokes at 0 F	1,025	1,400	3,100	4,700	7,200	8,900	20,000
Centistokes at —20 F	3,950	5,550	14,000	23,000	38,000	50,000	.....
Centistokes at —40 F	22,500	35,000	.....	.....	.....	.....	.....
Viscosity index, (ASTM D-567-41)	148	148	146	144	143	141	137
Pour point, F, (ASTM D-97-39)	—55	—50	—40	—35	—30	—25	—20
Flash point, open cup, F, (ASTM D-92-45)	300	410	425	430	430	430	430
Fire point, open cup, F, (ASTM D-92-45)	350	460	490	500	505	510	510
Density, g/cc							
At 210 F	0.919	0.921	0.930	0.935	0.938	0.939	0.942
At 100 F	0.965	0.967	0.975	0.980	0.983	0.984	0.987
At 60 F	0.981	0.983	0.992	0.996	1.000	1.001	1.003

TABLE II

Typical Properties of Standard Grades of LB-X Series Lubricants

Standard grade	LB-140-X	LB-170-X	LB-300-X	LB-400-X	LB-550-X	LB-650-X	LB-1220-X
Viscosity							
Saybolt seconds at 210 F	44.9	48.4	62.7	74.3	93.1	106	183
Saybolt seconds at 100 F	140	170	300	400	550	650	1,200
Saybolt seconds at 0 F	5,820	8,000	18,400	26,600	40,400	50,500	110,000
Centistokes at 210 F	5.7	6.80	11.0	14.1	18.8	21.9	39
Centistokes at 100 F	29.8	36.5	65.0	86.6	119	141	260
Centistokes at 0 F	1,270	1,740	4,000	5,800	8,800	11,000	24,000
Centistokes at —20 F	5,100	7,200	18,500	29,000	47,000	.....	.....
Centistokes at —40 F	34,000	50,000	.....	.....	.....	.....	.....
Viscosity index, (ASTM D-567-41)	140	144	142	141	141	140	136
Pour point, F, (ASTM D-97-39)	—50	—45	—40	—30	—25	—20	—15
Flash point, open cup, F, (ASTM D-92-45)	345	440	490	490	490	490	490
Fire point, open cup, F, (ASTM D-92-45)	410	530	585	595	600	605	610
Density, g/cc							
At 210 F	0.918	0.924	0.933	0.936	0.938	0.939	0.943
At 100 F	0.967	0.971	0.979	0.981	0.984	0.985	0.989
Specific gravity, 60/60 F	0.985	0.990	0.997	0.999	1.001	1.002	1.007

TABLE III

Typical Properties of Standard Grades of 50-HB Series Lubricants

Standard grade	50-HB-55	50-HB-170	50-HB-260	50-HB-400	50-HB-660	50-HB-2000	50-HB-3520	50-HB-5100	50-HB-280-X
Viscosity									
Saybolt seconds at 210 F	34.3	51.0	63.8	84.5	125	335	558	781	64.6
Saybolt seconds at 100 F	55	170	260	400	660	2,000	3,520	5,100	280
Saybolt seconds at 0 F	712	5,050	9,200	16,000	30,700	115,000	220,000*	330,000*	11,400
Centistokes at 210 F	2.4	7.6	11.3	16.7	26.2	72	120	168	11.5
Centistokes at 100 F	8.9	36.5	56.2	86.6	143	433	762	1,104	60.6
Centistokes at 0 F	155	1,100	2,000	3,500	6,700	25,000	48,000*	71,000*	2,480
Centistokes at —20 F	460	4,000	7,700	14,000	26,000	.....	.....	.....	9,800
Centistokes at —40 F	1,800	20,000	45,000	.....	.....	.....	.....	.....	.....
Viscosity index (ASTM D-567-41)	97	156	153	149	144	133	.....	.....	150
Pour point, F (ASTM D-97-39)	—85	—45	—40	—35	—30	—25	—20	—20	—35
Flash point, open cup, F (ASTM D-92-45)	260	410	410	430	430	440	440	450	500
Fire point, open cup, F (ASTM D-92-45)	285	475	500	535	545	545	545	545	600
Density, g/cc									
At 210 F	0.920	0.967	0.977	0.984	0.991	0.998	1.001	1.003	0.976
At 100 F	0.972	1.014	1.023	1.030	1.037	1.043	1.046	1.048	1.024
At 60 F	0.993	1.031	1.040	1.047	1.054	1.060	1.063	1.065	1.048

*Extrapolated value.

2. *Burn-off properties*—Closely allied to the non-sludging characteristics is the essentially complete burn-off obtained with these synthetics when maintained without replacement at elevated temperatures. This property is attributed to the volatility of their oxidation and decomposition products and minimizes the formation of undesirable carbonaceous deposits.

TABLE IV

Typical Properties of Representative 75-H Series Lubricants

	75-H-490	75-H-1400	75-H-9150
Viscosity			
Saybolt seconds at 210 F	88	197	1,187
130 F	258	700	4,720
100 F	490	1,400	9,150
Centistokes at 210 F	17.5	42.6	257
130 F	55.6	151	1,020
100 F	106	303	1,980
Viscosity index (ASTM D-567-41)	143	135	.....
Pour point, F, (ASTM D-97-39)	5	20	40
Flash point, open cup, F (ASTM D-92-45)	445	475	405
Fire point, open cup, F (ASTM D-92-45)	525	.....	490
	525	.....	490
Specific gravity, 20/20 C	1.092	1.093	1.089
Density, g/cc			
At 210 F	1.030	1.030	1.027
At 100 F	1.076	1.077	1.073

3. *Effect on rubber*—An interesting property of the synthetic lubricants is their low solvent and swelling effect on most natural and synthetic rubbers. In general, the swelling or softening effect is negligible, however in some cases plasticizers or other compounding ingredients have been removed from synthetic rubbers because of the solvent action of the oil. Swelling data for typical lubricants with various types of rubbers are shown in Table V.

4. *Solubility relationships*—As mentioned previously, members of the "50-HB" and "75-H" series are soluble in water at normal temperatures. This permits the formulation of aqueous solutions of the lubricant which have been shown to be of value as textile fiber and rubber lubricants. This unique property will undoubtedly result in the development of other interesting applications. Although the "LB" series is frequently characterized as being water insoluble, this classification is apt to be misleading. In actuality, members of this series will dissolve up to 3 per cent water in true solution at normal temperatures. This enables the lubricants to take up small amounts of water contamination without the formation of troublesome, emulsion-type sludges.

Since the synthetics have different molecular structures than those of conventional oils, one would expect different solubility characteristics. This behavior is readily apparent in the case of water. The mutual solubility relationships of these polyethers with organic solvents, mineral and vegetable oils, and various natural and synthetic resins are equally interesting. Representative data showing the solubility of these fluids in selected organic solvents are shown in Table VI. For some applications these characteristics may prove to be favorable to the synthetics, and in others they may prove unfavorable. In either case, it should be empha-

TABLE V

Effect of Synthetic Lubricants on Rubber

Rubber	Linear per cent swelling		Condition of immersion
	LB-285	50-HB-260	
Natural	2 to 3	—1 to 1	5 Days, 160 F
Buna S	8 to 10	1 to 2	20 Days, 212 F
Buna N	0 to —1	0 to 1	5 Days, 160 F
Butyl	0 to —2	—2 to —3	20 Days, 212 F

TABLE VI

Solubility of Selected Synthetic Lubricants in Various Organic Solvents (Solubilities determined at room temperature unless otherwise specified.)

Solvent	Lubricant	
	50-HB-260	LB-400
Acetone	S	S
Benzene	S	S
Carbon tetrachloride	S	S
Ethylene glycol	I (SH)	I (SH)
Glycerine	I	I
Heptane	I	S
Kerosene	I	S
Methanol	S	S
Petroleum ether	I	S
Toluene	S	S
Water	S (IH)	I

Key: S — Soluble; SH — Soluble, hot; I — Insoluble; IH — Insoluble, hot

sized that these synthetic lubricants exhibit many unusual solubility relationships.

USES OF THE LUBRICANTS

During the past two years there have been many instances in which the unique properties of these synthetics have met the requirements of certain industrial lubrication problems. The high temperatures and drastic conditions encountered throughout the iron and steel industry are providing a wide number of such applications and there is no doubt that many more will be forthcoming. A discussion of the available and pertinent details of some of these specific uses is presented as an indication of the type of performance which may be expected from the synthetic lubricants.

HYDRAULIC OILS

Precision machine tools—The combination of viscosity-temperature properties and non-sludging characteristics would appear to render the synthetics of value as oils for hydraulically actuated precision machine tools. Fluids such as LB-140-X, LB-170-X, and LB-300-X have been used as the actuating fluid in various hydraulically operated milling and grinding machines. In all of them, excellent performance characteristics have been reported. Of principal interest is the reported cleanliness of the hydraulic systems and the elimination of gumming and valve clogging troubles. In several instances it was stated that difficulties due to coolant and emulsifiable cutting oil leakage were eliminated. One difficulty which has been noticed in connection with this application is the tendency, in a few instances, for the synthetic oil to exert a solvent action on some types of paints. For this reason, it would be desirable to check the effect of the oil on any paints in the system prior to filling the system with the synthetic oil.

Pressure welding machine—Another closely related application, largely dependent on the favorable viscosity-temperature-pressure relationships, is the use of the synthetic oils in various types of equipment employing hydraulic pressure. A typical instance is the use of LB-140-X in a pressure welding machine where constant pressures must be maintained throughout an appreciable ambient temperature range. A picture of a section of the machine is shown in Figure 2. This unit is equipped with a two-stage vane pump delivering 4.5 gallons per minute at a constant pressure of 1500 psi and powered by a 7½ hp motor. The unit operates from 8 to 10 hours per day.

A good grade of an SAE 20 oil was previously used. Frequent renewals were necessitated, oil foaming had been a problem, and it had been difficult to maintain constant pressures over a range of oil and ambient temperatures. After introducing LB-140-X into the system, it was observed that the unit would operate at constant pressures regardless of the operating temperature of the oil. It would start on a cold morning with the same valve setting as was used during operation on a hot day. Ambient temperatures have ranged from —4 F to 100 F, and oil temperatures have run as high as 160 F. At the high oil temperatures, it had not previously been possible to obtain pressures in excess of 1000 psi when using the SAE 20 oil.

At the last report, LB-140-X had outlasted the mineral oil by more than 2 to 1 and was still performing satisfactorily with no evidence of oil deterioration.

Hydraulic presses—A similar application is the use of LB-300-X in a 500-ton hydraulic press. This machine is equipped with a two-stage vane pump, delivering 25 gallons per minute at a pressure of 2000 psi and powered by a 60 hp motor. The synthetic lubricant has been in the equipment for the past year and the principal observation has been that there is much less difficulty in maintaining pressures at high oil temperatures than there was previously.

In general, favorable reports have been received relative to the adaptability of the synthetic lubricants for all types of hydraulic equipment which must operate over wide temperature ranges. Of particular interest are hydraulic hoists, lifts, riveters, and road building machinery.

FIRE RESISTANT HYDRAULIC OILS

During the war, the demand for aircraft hydraulic fluids possessing low flammability characteristics resulted in the development of the so-called hydrolube fluids by the Naval Research Laboratory (6-9). These fluids are prepared by blending together, water, ethylene glycol, and a high viscosity soluble polymer and by adding to this mixture a combination of liquid and vapor phase inhibitors. Such a fluid is described in U. S. Navy Department, Bureau of Aeronautics, Specification 51F22 (Aer.). One of the fluids conforming to the requirements of this specification is known as hydrolube "U" and contains 75-H-73,500, as the polymer thickening agent. Satisfactory performance of this fluid in aircraft hydraulic systems has been reported. Properties of hydrolube "U" are tabulated in Table VII.

Because of the interest which has been expressed in this type product by manufacturers and users of hydraulic equipment operating under conditions when the hydraulic oil constitutes a definite fire hazard, more viscous fluids of the same type as hydrolube "U" have

been formulated by increasing the concentration of polymer. The water concentration has been maintained so that the flammability of the thicker fluids is not appreciably altered. Properties of two typical thickened hydrolube fluids having higher viscosities than hydrolube "U" are also included in Table VII.

TABLE VII

Properties of Three Hydrolube-Type Hydraulic Fluids

	Hydrolube "U"	Hydrolube "300"	Hydrolube "550"
Viscosity			
Centistokes at 130 F	10.0	34.5	70.9
100 F	16.5	59.5	119
20 F	116.5	485	990
0 F	247.4	1,213	2,378
—20 F	614	2,968	.....
—40 F	1,797	9,753	.....
Saybolt seconds at 100 F	83.3	275	551
Density, g/cc			
At 130 F	1.059	1.064	1.053
At 100 F	1.070	1.076	1.066
At 60 F	1.085	1.033	1.083
Freezing point, F	Below —76	Below —60	—15
Boiling point, F	211	209	209

These hydrolube-type fluids represent a relatively new development, but the interest which has been expressed in them during the few months since they have become commercially available indicates that there are many instances where fire retardant hydraulic media are in urgent demand. Typical of the types of equipment in which these products have been tested are the following:

Die casting machinery—A prominent manufacturer of zinc and aluminum alloy die castings has been using one of these hydrolube-type fluids in hydraulically operated die casting machines for the past six months. These machines, having a capacity of 105 gallons of fluid, are equipped with vane pumps, and produce hydraulic pressures from 1000 to 1500 psi. Consumption of the fluid has been extremely low, since the hydrolube fluid does not appreciably attack the rubber hose lines in the system. Leakage in these lines had formerly contributed to the fire hazard. A report of this usage was recently presented before the American Society of Die Casters (10).

Manipulators—One of the applications which should be of particular interest to those in the iron and steel industry is the use of these low-flammability fluids in hydraulically operated manipulators and similar types of equipment. The rupturing of hydraulic lines on machines of this type when used in forging shops or similar locations could result in a serious fire hazard when accompanied by impingement of the petroleum hydraulic oil on a hot metal surface. A 6000-pound auto floor manipulator is shown in Figure 3. One of the hydrolube hydraulic fluids has been in operation in two of these machines since March, 1947, and satisfactory performance has been reported. An inspection of the rotary piston-type pump, which activates the hydraulic system, after four months of operation showed the working parts of the pump to be in excellent condition. This pump operates at 850 rpm and 1200 psi, and the rated displacement is 25 gallons per minute.

Hydraulic presses—The same concern has also installed the hydrolube-type fluid in a 150-ton hydraulic press located in their blacksmith shop. The press is powered by a pump which operates at 1140 rpm and 2500 psi. Completely satisfactory performance has been reported during the six months that the hydrolube fluid has been in the press.

Other applications where the added safety of using a fire-resistant hydraulic fluid would be desirable include such equipment as furnace and combustion controls, mud guns, and various types of mining machinery. The synthetics are currently being evaluated for these uses.

HIGH TEMPERATURE LUBRICANTS

The superior burn-off properties and the non-sludging characteristics of these synthetic lubricants would indicate their suitability for certain high temperature applications. In this connection, the following uses are typical of those which have been developed.

Lubrication of glass manufacturing machinery—In view of the high operating temperatures encountered in the glass industry, it is not surprising that the synthetic lubricants should be particularly desirable for glass manufacturing machinery. Pictures of two bearings are shown in Figure 4. These bearings were removed from the rolls used to smooth and regulate the thickness of large glass sheets and operate at temperatures in the vicinity of 900 F. Although lubrication at these temperatures is not feasible, it is necessary to flush the bearings with oil periodically to maintain smooth operation of the rolls. The sludging encountered with mineral oil necessitates bearing replacement about every two months. The two bearings shown in the picture were installed at the same time in the same machine under as nearly identical conditions as possible. One of the bearings was flushed with mineral oil in the usual manner, and the other was flushed at the same time with equal quantities of LB-1145. Both bearings were removed when some of the mineral oil lubricated bearings in the machine failed because of excessive carbonization. Inspection showed the bearings lubricated by the synthetic to be relatively clean and in operating condition, while the others were frozen and clogged with hard deposits. Wear measurements indicated no appreciable differences in the diameters of the bearing rolls. The

Figure 2 — Hydraulic machines, which must maintain constant pressure at various ambient temperatures such as this pressure welding machine, have had better service with the synthetic oils.

first machine in which these bearings have all been lubricated with the synthetic lubricant has been in operation for nearly a year without having to shut down for bearing replacement.

Another established application in the glass industry is the specification by a prominent manufacturer of LB-550-X as the lubricant for the revolving turrets of the hot cut flare machines used in the forming of light bulbs and related items. The minimization of sludge formation was the quality which again rendered the synthetic lubricants of value in this type of usage.

Graphited lubricant — The previously mentioned burn-off characteristics have been shown to be desirable in the development of graphited lubricants with one of the synthetics as carrier. Oven chain lubricants have been formulated which are characterized by the deposition of a soft, flaky, graphite coating after the carrier has burned off. This is in contrast to the "baked-in" graphite coating which is frequently encountered when mineral oils are used as carriers. These lubricants are currently being used in bakeries and in industrial baking and drying ovens.

Packing impregnant—A packing manufacturer has reported that LB-1200-X is an excellent impregnant for asbestos steam packings. After these packings have been exposed to steam temperatures for prolonged periods of time, they remain pliable and can be relubricated. Mineral oil impregnants, which had previously been used, tended to carbonize and resinify with the resultant formation of hard, brittle packings which had to be replaced.

Heat transfer media—The improved heat stability of the synthetic lubricants has resulted in their frequent use as bath and heat transfer media in the 200-500 F range. In one instance, a closed system, equipped both for heating and cooling the liquid in a rubber compounding mixer, was filled with 50-HB-280-X and has been in intermittent operation for a period of several months at temperatures ranging from 300 to 500 F. At the same plant this fluid is used in a vented laboratory bath which has been continuously maintained at 490 F for a similar period with a negligible viscosity change. Another plant has been using the synthetic in all of their laboratory baths at temperatures ranging from 100 to 300 F. Metal heaters and parts immersed in the mineral oil bath had previously become coated with hard carbon deposits as much as ½ in. in thickness after two to three months of operation, and the bath oil had to be replaced frequently. After over a year of operation with the same fill of synthetic fluid, all metal parts are clean and the viscosity of the bath oil is essentially unchanged. In these and in other similar instances, the elimination of sludging difficulties has been particularly noteworthy. Volatilization of the fluid has not been excessive, although it increases appreciably at higher temperatures and the desirability of using closed, vented systems at temperatures in excess of 300 F is indicated.

The examples cited above have been selected from various industries. Undoubtedly, steel mills and metal fabricating plants will offer many applications where the same unique properties of these synthetics can be utilized.

Figure 3 — This 6000 lb floor manipulator's hydraulic system, because of its use around flame and hot metal, can be more safely operated with a fire-resistant oil.

METAL FORMING LUBRICANTS

Several specialized metal drawing applications have been reported. Among them are the use of 50-HB-400 as the lubricant for drawing nickel silver and high phosphor bronze alloys and the use of 75-H-47,000 in the deep drawing of high nickel alloy transformer shields. It has also been found that 50-HB-400 is an excellent lubricant for drawing certain special high carbon steel wires. The synthetics seem to be readily adaptable to the drawing of tough, high tensile strength metals, for which aqueous solutions of soaps or soluble oils are frequently inadequate. They offer the definite advantage of ease of removal from the metal surface, either by completeness of burn-off in subsequent heat treating operations or, in the case of the water soluble lubricants, by water washing.

Another possibility which should not be overlooked is that of utilizing these synthetic lubricants as carriers for various types of additives used in conventional metal forming operations. One manufacturer has been studying the performance characteristics of different additives in 50-HB-400 as the lubricant for drawing stainless steel wire. Another concern is blending palm oil with LB-385 as a lubricant for drawing a tough, silver brazing alloy. Straight palm oil had been difficult to handle due to solidification and tended to become rancid with use. Although LB-385 performed satisfactorily, the die life was not as high as had been obtained with palm oil. The finished blend is said to incorporate the best features of both lubricants with none of the disadvantages of either. It is expected that the addition of certain colloidal graphite suspensions to various polyether lubricants or their aqueous solutions will also offer many promising applications in the field of metal working.

Of interest to the steel industry is the possibility of utilizing the synthetic lubricants as roll oils for the cold reduction of steel strip. The superior burn-off characteristics should offer a definite improvement over palm oil and might make possible the elimination of a cleaning operation. Details of this application are currently being investigated in the laboratory.

RUBBER LUBRICANTS

The fact that both the "50-HB" and "LB" series

lubricants show relatively little solvent or softening action on most types of natural and synthetic rubbers has resulted in their rapidly expanding use in applications involving rubber processing and lubrication. The success of the synthetics as hydraulic brake fluid constituents is to some extent dependent upon this property (3, 5). Many tire manufacturers are using aqueous solutions of the 50-HB series as air bag lubricants in the molding and curing of tires. Other rubber fabricators have found that the water soluble fluids may be used as rubber mold lubricants. One manufacturer is using 50-HB-3520 as a mandrel lubricant in the fabrication of automobile radiator hoses. Another interesting use is that of 50-HB-3520 and LB-1145 as cutting oils for threading hard rubber storage battery caps. Several of these fluids, blended with suitable solvents, are being marketed as rubber shackle lubricants, and members of the "LB" series, in general, are serving as water insoluble lubricants for rubber bearings and joints. One concern has reported the adoption of LB-300-X for lubricating the rubber O-rings of pneumatic equipment throughout their plant. Ring replacement has dropped to about one-tenth the previous rate and a full time maintenance employee is no longer needed.

The above examples serve as an illustration of the adaptability of these synthetic lubricants in solving rubber lubrication problems. There are undoubtedly other instances where the same properties could be utilized.

MISCELLANEOUS APPLICATIONS

The uses which have been described are by no means all inclusive. Additional examples which are indicative of the wide range of utility of the synthetic lubricants are mentioned briefly below.

Electric motor lubricants—The lubrication of electric motors is an application in which sludging difficulties are frequently encountered. Reports have been received from a large plant which has used LB-300-X as the lubricant for 100 hp motors that maintenance shutdowns caused by the excessive sludging of mineral oil lubricants were practically eliminated during a period of the war when continuous operation was of vital importance. It is also of interest that a prominent manufacturer of fractional horsepower electric motors, after conducting exhaustive tests with various bearing materials, is adopting the low viscosity LB-X fluids as lubricants for certain wick-lubricated motors.

Low temperature lubricants—The low pour points and favorable viscosity-temperature relationships of these synthetics point toward their use in lubricant and hydraulic applications involving low temperatures. Of interest in this connection is the recommendation of LB-300-X by a manufacturer of industrial deep-freeze equipment as the lubricant for the motors used in the equipment. These motors operate at ambient temperatures ranging from -10 to 0 F. Another application is the use of an LB fluid as the lubricant for the push rods on liquefied hydrocarbon gas pumps. The synthetic prevents ice formation and has greatly increased the life of the packings.

Vacuum pump lubricants—The non-sludging characteristics of various members of the LB series point to their use as vacuum pump lubricants. Reports have been received from several sources that the use of these lubricants has resulted in much cleaner pump systems and that the solvent action of the synthetic fluid has effectively cleaned pumps which had heavy petroleum sludge deposits.

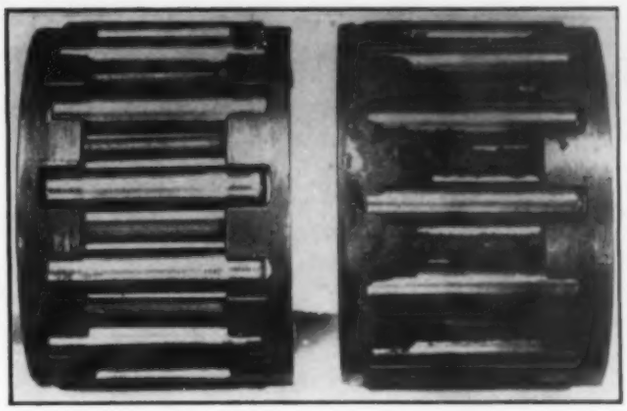


Figure 4 — These two bearings saw the same amount of service on glass rolling machinery. The one on the left was lubricated with lubricant LB-1145; that on the right by a good grade mineral oil.

Greases—A series of specialty greases which are characterized by their applicability over wide temperature ranges, stability, high dropping points, and low rates of bleeding have been prepared in experimental quantities. Bearing life tests of these greases indicate their suitability for both low temperature and high temperature usage. While they are not, at present, commercially available, it is expected that they soon will be. Typical properties of three of these greases are presented in Table VIII.

TABLE VIII

Properties of Some Typical Synthetic Greases

Grease	Operating range, degree F	Water solubility, per cent	Dropping point, degree F	Penetration
LT-64-F	—100 to 250	31	365	235
HT-1200	— 15 to 300	20	402	237
WS-400	— 15 to 220	Completely Soluble	333	250

This synthetic lubricant development is new and data from many of the uses are incomplete and of a fragmentary nature. Several of the specific applications which have been discussed appear to have little connection with the iron and steel industry, but the particular characteristics of these synthetic lubricants which have established them in these applications are characteristics which have a wide range of possible utilization. It is hoped that the information which has been presented will be of interest and value to lubrication and hydraulic engineers in the solution of some of their specific problems.

In many instances the cost of the lubricant or hydraulic fluid represents a very minor part of the cost of machines, servicing, repairs, and production loss due to shutdowns and inefficient operation. Therefore, super-

ior performance of the lubricant or hydraulic fluid can easily justify the inherently higher costs of the synthetics. Without doubt there are many applications in the iron and steel industry in which these synthetic lubricants will fill a long awaited need and for which their use will be economically justified.

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DISCUSSION

PRESENTED BY

S. C. GRIFFITH, Lubrication Engineer, Jones and Laughlin Steel Corporation, Pittsburgh Works, Pittsburgh, Pennsylvania

J. H. LEWIS, Lubrication Engineer, Carnegie-Illinois Steel Corporation, Clairton Works, Clairton, Pennsylvania

R. A. KRAUS, General Millwright Foreman, Republic Steel Corporation, South Chicago Works, Chicago, Illinois

W. H. MILLETT, Carbide and Carbon Chemicals Corporation, Tonawanda, New York

C. E. PRITCHARD, Chief Lubrication Engineer, Republic Steel Corporation, Cleveland, Ohio

J. D. LYKINS, Lubrication Engineer, Wheeling Steel Corporation, Yorkville Works, Yorkville, Ohio

J. E. SULLIVAN, Vice President, Edgar E. Brosius Company, Sharpsburg, Pennsylvania

R. S. SHOEMAKER, District Manager, Brooks Oil Company, Middletown, Ohio

S. C. Griffith: There is no one here who has not had previous contact in some manner with the synthetic type of lubricant. However, the term synthetic can easily connote the thought of a substitute product, and the inference is drawn that substitute products do not merit any particular consideration. This interpretation must be avoided very carefully in order to appreciate what is being offered by these relatively new materials.

In any analysis these four factors should be considered:

1. By its very definition, a lubricant is not classified by any predetermined pattern.
2. Fluid and grease type conventional lubricants have recognized limitations in their properties which restrict their successful performance under certain operating conditions.
3. Synthetic lubricants have a series of unusual properties which are inherently related to their chemistry and which, by customary standards, are both superior to and inferior to conventional lubricants.
4. Synthetics have not been developed and introduced as replacement products but rather as a new means of improving operations.

A review of the various properties of the materials that have just been presented does not add anything of value to this session. However, these properties do merit very careful consideration in view of the practical data contained in the discussion. It is a mistake to assume arbitrarily that synthetics have no application in the operations with which we are individually familiar. The acceptance, as unavoidable and routine, of a costly maintenance and operating practice is too easily assumed. A recent experience illustrated that point very forcibly.

It is unreasonable to enlarge further upon this matter because of limited personal experience. However, this thought may be emphasized. The synthetics that have been presented are not untested laboratory phenomena but are materials with exceptional qualities which have a very definite practical field of application.

J. H. Lewis: From what experiences I have heard about—not that I have had myself—with synthetic lubricants, I feel that there is a lot of work to be done in designing equipment for heavy industry before we go into that particular type of lubricant. I do not think there is enough production on it now so that we could go into it on the basis of price.

Due to the fact that a lot of our equipment would not be able to retain it, if we went into it on a large scale, the benefits we would derive from a good lubricant we would lose, on the other hand, in cost. I think a lot of work has to be done in designing equipment before we can actually go into a real use of synthetic lubricants.

R. A. Kraus: The result which undoubtedly will be obtained from continued research in non-hydrocarbon synthetic lubricants will possibly be of great value in the future. This will be particularly true as the better producing wells are expended and as the more marginal supply sources for conventional petroleum lubricants are forced into service in order to maintain the continued high production rate of petroleum products. These marginal sources will in all likelihood force the cost of producing the conventional petroleum products higher, with the result that use of the more expensive synthetic products will ultimately become economically sound for more and more industrial applications. Similarly, the use of synthetic petroleum products made by hydrocarbon transformations will, potentially at least, become of greater importance. Petroleum products of this type were used successfully to an increasing extent by both our enemies and our ally, China, during the recent conflict when these countries found their conventional petroleum lubricants and fuels in short supply. Ultimate shortages of the natural product in the future may

again force a similar production to supply the world's needs for these materials.

As more present day practical applications are found for the non-hydrocarbon synthetic material, thereby increasing the total present day consumption, economics dictates a probable decrease in the manufacturing cost, which in turn will bring nearer the day when a more favorable cost comparison can be made for more industrial applications. In regard to these potential new applications for the synthetic lubricants, I would like to ask several questions regarding data that was not brought out in the paper.

1. When making a substitution involving the replacement of a given viscosity straight mineral oil with your synthetic lubricant, what viscosity relationship will hold in order to obtain equivalent lubricity?
2. In regard to the greases, what general characteristics can be expected?
3. Are the metallic soaps all soluble in the synthetic oils and what success has been had using carbon dispersions as thickening agents?

W. H. Millett: In answer to the first question, if the application is one involving hydrodynamic lubrication, the primary consideration would be to have the same viscosity at the operating temperature as you have with a suitable mineral oil. This will frequently give an advantage at starting temperatures, or throughout the operating temperature range. For hydrodynamic lubrication problems, select the viscosity of synthetic such that it will be the same as the petroleum product in the operating range. In these instances, the effectiveness of a lubricant is largely a function of viscosity and it would be desirable to choose the lubricant on the basis of viscosity at the operating temperatures.

R. A. Kraus: In those conditions where boundary conditions exist, would you say that the needs are for equivalent viscosities?

W. H. Millett: We are investigating the boundary lubrication picture in the laboratory, and have been evaluating various basic types of mineral oils, such as midcontinent, naphthenic and paraffinic oils; and comparing them with the synthetic product without the use of film strength additives, either in the mineral oils or in the synthetic. In general, they fall in the same categories as the mineral oils as far as the extreme pressure load-carrying capacities are concerned, evaluating them in such laboratory machines as the SAE, the Timken, the Falex, and the Shell 4-ball machine.

The lubricant which, in one instance will appear to have a slight superiority, will in other instances be found to be inferior. For example, in a series of Timken machine tests, a certain paraffinic oil was shown to be slightly superior in load-carrying capacity to a synthetic lubricant of comparable viscosity, whereas naphthenic- and mid-continent-type oils were shown to be slightly inferior. In Shell 4-ball machine tests, however, the polyether synthetic lubricants have been found to have an appreciably greater load carrying capacity than any straight mineral oils of comparable viscosity.

R. A. Kraus: Then in general we can say that across the whole range from hydrodynamic or fluid friction through boundary conditions, the requirements for equivalent lubricity indicate that similar or equivalent viscosity relationships will hold.

W. H. Millett: That is right, I think we would be safe in making that assumption.

Your next question was: "In regard to the greases, what general characteristics can be expected?"

What type of characteristics are you referring to?

R. A. Kraus: You did cover the subject of grease to a minor extent in your paper, but I am inquiring whether all metallic soaps are soluble in your synthetic oil.

W. H. Millett: No. In fact, most conventional soaps when compounded into greases by customary methods using the polyether lubricants as the base fluid do not yield stable grease structures. However, exceptionally stable greases can be prepared by resorting to slight variations in the soap and in blending technique. The following information is of interest: bleeding and evaporation losses for the high temperature grease, HT-1256-A, after 50 hours at 340 F were found to be 0.2 and 3.5 per cent, respectively. Comparable values for the low temperature grease, LT-64-F, in 50 hour tests at 212 F were: bleeding, 0.2 per cent, evaporation, 0.9 per cent.

R. A. Kraus: What types of soaps are used in these greases?

W. H. Millett: Lithium soaps are used.

R. A. Kraus: What has been your experience regarding the pumpability of the various products?

W. H. Millett: We find that, in this particular, the synthetics offer a certain advantage, especially at low temperatures. These lubricants can be pumped at temperatures below their pour points in view of the fact that they contain no wax and the pour point is a so-called "viscous pour."

We have done very little with carbon dispersions as thickening agents, although it is certainly a promising field.

In regard to Mr. Lewis' comment, I would like to mention that we realize that these products are somewhat more expensive than conventional lubricants. Efforts are being made to find places where they fit in and where they can do a better job and one that is economically justified on the basis of cost. I also wish to reiterate that in view of the high cost of equipment and machinery and the expense of shutdowns and inefficient operation, there are many instances in which higher initial lubricant cost, although it may look a bit startling at first, is not going to prove as expensive as it might seem and may in the last analysis provide substantial savings.

C. E. Pritchard: The usage of synthetic lubricants is something that I feel certain will definitely be of interest to us all in the future. However, there are a lot of questions that are still to be answered as to their practical limits in field applications.

The one that seems to come to mind at the present time is in direct relation to the cold rolling field, or cold rolling practice. What has been your experience in regard to the comparative spreading rate of synthetic versus the conventional mineral oil?

W. H. Millett: No spreading rate measurements have been made, although the problem is being investigated. As far as the surface wettability is concerned the synthetic lubricants may be expected to do as well as petroleum oils, as evidenced by a wide background of engine

tests and similar applications, where there has been no evidence of inadequate wetting. In this particular problem the spreading rate is a factor that will have to be considered.

C. E. Pritchard: I might mention that the reason for the question is that in our own field experience, we had occasion to run an experimental test involving the usage of one of the synthetic lubricants, such as were mentioned in your paper. It was applied by the drip method onto the strip surface during the cold rolling operation and definitely did not show the same spreading rate as was experienced with a conventional mineral oil similarly applied. The same product properly esterified did a decidedly better job in this respect.

W. H. Millett: That will undoubtedly be the answer, getting more polar groups into the lubricant, and that is the approach being followed in the laboratory. This may be accomplished either by modifying the basic synthetic molecule to give increased spreadability, or by adding polar additives that will tend to wet the surface to an even greater extent.

C. E. Pritchard: I have one other question, The suffix "X" seemingly has been referred to in practically every example given. I presume that it is an inhibited product, and, if so, why is it so much a generality, if your original comments are correct?

W. H. Millett: The "X" represents the presence of an oxidation inhibitor. In most instances involving high temperature applications, the oxidation inhibitor is needed to delay the oxidation of the fluid resulting eventually in volatilization and dissipation of the lubricant. In the presence of the antioxidant, the lubricants have a much longer life and do not break down as rapidly as without the inhibitor. In some particular applications, a clean "burn-off" is desired. In these cases, the antioxidant would not be included, and the lubricant would pass off as volatile decomposition products without leaving any appreciable residue.

C. E. Pritchard: The next question is in regard to your comments covering the usage of the synthetic lubricants for cold drawing of carbon bars. I would like to ask at this time what the effect has been in field practice regarding the contamination of the lubricant with lime sludge.

W. H. Millett: We have had no experience in that regard to the best of my knowledge.

J. D. Lykins: I have no comments on the paper, but I do have a question. In the steel industry, especially where we have our older equipment and machinery that has been speeded up, we have excessive loads. What has been done to increase the film strength of the lubricant, that is, are extreme pressure additives added?

W. H. Millett: A program has recently been started in connection with this problem as mentioned previously. Work is in progress on various load-carrying machines with lubricants containing commercially available extreme pressure additives. Experiments are also being made with other types of additives suitable as film strength improvers in the thin film lubrication range. Indications are that the commercially available extreme pressure additives, if soluble in the synthetic lubricants, work very well under extreme pressure conditions. We do not have much specific information on this at the present time.

J. E. Sullivan: Our experience is very limited. We just tried this synthetic in March of 1947 with two machines in Altoona. We were very apprehensive about it because the pump involved was a very delicate piece of mechanism, and we have been told not to use anything but extra heavy oils. Mr. Schmidt, who is the chief engineer, decided to go ahead with it, and it has been running now for six months, and we have been getting very good results. That is as much as we know at the present time.

R. S. Shoemaker: The first sentence in the paper says, "In recent years there has been a widespread interest in the commercial availability and utilization of various types of synthetic oils and lubricants." There certainly is a widespread interest in this material. We are all very much interested to know how far we can go with it. The price of this material is one of the outstanding factors which, of course, is working against its use at the present. One of our previous speakers expressed the hope or the probability that the cost of regular lubricants would come up and eventually meet this high price. Speaking for the steel industry, I hope it will go the other way. Prices are high enough.

Another question I had in mind is, what are the extreme pressure qualities of this material? I want to know how they compare with ordinary extreme pressure lubricants as we know them and use them today. These oils seem to have just about everything that anybody could desire in a lubricant. I would like to hear another word or two on the extreme pressure qualifications.

W. H. Millett: This has to some extent been covered in answer to previous questions. We find, for example, that lead naphthenate, a familiar type of extreme pressure additive, is effective, but that compatibility at lower temperatures is somewhat questionable. A good many of the commercially available extreme pressures are usually obtained in oil solution, and it is difficult to work with them because of incompatibility with mineral oil. However, we have found some that seem to be equally as effective as the best currently available extreme pressure additives based on results in the extreme pressure test machines.

Member: Mr. Millett has mentioned the addition of polar groups to improve the synthetic lubricant for the cold rolling of steel. I would like to know how they expect to approach that end, that is, to get these polar groups into the product.

W. H. Millett: One method would be by the utilization of additives with polar characteristics. Another would be by modifying the basic synthetic molecule by putting a stronger polar group on the terminal grouping of the molecules. This might enhance its adherence to metal surfaces or its spreadability if that is the property that is desired.

Palm oil, which is currently used as a roll oil, has a very strong polar group. The incorporation of palm oil, or a material having similar characteristics to palm oil, as a blend with the synthetic lubricant might achieve that end.

Member: To what extent would oxygen enter into your program on adding these polar groups to your product?

W. H. Millett: These are oxygenated molecules, and they probably could very well be oxygenated groups.

Controls for Multiple Fuels

By WILLIAM F. PRAY
Askania Regulator Company
New York

. . . . the increasing necessity for substitute fuels increases the application of and need for automatic control systems for fuel handling . . . .

▲ WHILE the fuel problem is ever present, it has been considerably aggravated in the past few years by causes all too well known. During the last few years natural gas has become very popular as a fuel for industrial use, but unfortunately it is frequently not too dependable a fuel. Furthermore, we not only have short supplies to contend with, but the economic situation is important as well. Fluctuating prices of fuel oil may make it advisable to change from oil to gas and vice versa and frequently at short notice. All of these things make the life of the fuel engineer not too happy, not to mention the difficulties encountered by the producing departments as well.

It has been shown that much greater flexibility, more continuous operation and more immediate availability of substituted fuels are all greatly encouraged by properly designed and installed automatic control systems for fuel handling. The reverse is also true. The almost universal use of automatic control in fuel burning processes, the wide use of inspirating burners, and other combustion equipment affected by any change of fuel makes the availability of a suitable interchangeable fuel greatly to be desired.

In using standby or substitute fuels, there are several steps which follow each other in a logical sequence:

1. We may completely substitute one fuel for another as would be the case in changing completely from gas to oil.
2. We may merely wish to augment a short fuel supply and, for instance, in the steel industry, would make up with fuel oil a partial shortage of coke oven gas in the open hearth furnace.
3. Further than this we might wish to make a complete or partial substitution of fuel for a whole mill.
4. During a period of shortage of coke oven gas we might substitute, partially or completely, a mixture of natural gas and air or propane and air.

In all of these cases the main objective is to provide a substitute fuel which causes the least disturbance in operation, adjustment of regulators, burner controls and general combustion equipment.

For combustion purposes, what we really want is to have all of our calculations and controls on a weight basis. Specifically we want to combine a certain number of pounds of air with the proper number of pounds of fuel for proper combustion. However, practical considerations make it necessary to carry on most of our metering processes for combustion control on a volume basis. In the case of gas, measurements are usually made by orifices. Figure 1 shows a basic method of automatic combustion control and you will see that it is really a problem of mixing on a volumetric basis. This is the basic method of mixing, whether it be air and fuel for direct combustion, air and fuel for plant gas supply or a plurality of fuels for direct combustion.

This is based on a volume measurement and it should be noted that the method of installation and the design of the system can have a considerable effect on the accuracy of the results. The orifice measurements are affected by both volume and density. If both gases are at low pressure, for all practical purposes barometric changes cancel out. If one gas is at high pressure and the other at relatively low pressure, barometer changes can have considerable effect. It is also obvious that if measures can be taken to assure both gases of being nearly the same temperature, it is possible to cancel out the effects of temperature changes. It has been suggested

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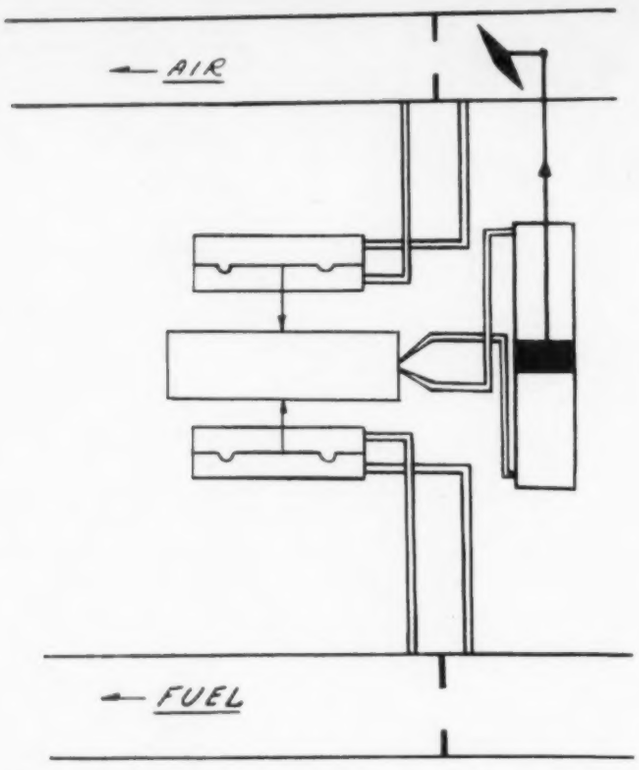


Figure 1 — Basic method of mixing fuels is the volumetric method.

in the past to run both gases through a heat exchanger in cases where a wide variation occurs between the two. As far as I know, this has never been done, but it is entirely possible. Another point that should be mentioned is, of course, that both flows to be measured must be in the same Reynolds number range.

Figure 2 is a variation of Figure 1 and shows the method of complete substitution of a single fuel, in this case, fuel oil for gas. Here we find the fuel oil measured by a positive displacement meter and the measurement translated into an air pressure which represents the same demand for air as did the differential pressure formerly received from the gas orifice. A system of this kind permits immediate substitution of oil for gas or vice versa with no interruption of operation, no involved control changes or adjustments.

Figure 3 shows a somewhat more complicated problem, but one which can be solved rather simply. It is the addition of a fuel to augment a partial, but not completely short supply of primary fuel. Here the problem is to supply automatically the air requirement for any combination of the two fuels. It is in effect an adding machine made up of the two basic regulators shown in Figure 1. Instead of having the fuel control combustion air directly, we make it control a pilot air flow which represents the demand for combustion air. These pilot air flow lines are about ¾ in. in diameter and are fed with air from a low pressure (a few inches of water) source. In the sketch, Fuel "A" is controlling the pilot air flow in one branch of what is called the summarizer, and as the flow of Fuel "A" varies, it in turn, varies the flow of pilot air proportionally. Fuel "B" operates in the same manner. The two pilot air flows are then added together in a single line, passed through an orifice, and the differential created by this orifice then is the demand for combustion air. This same system with variations may also be used as a fuel deficiency controller. It can be so set up that it will automatically add Fuel "B" as Fuel "A" becomes deficient.

We are sometimes asked why it is necessary to add the flows instead of merely adding their differentials which would be much easier for everybody concerned. Figure 4 is a brief explanation of what happens if we add the differentials instead of the flows. Basically it depends on the fact that the sum of the squares is not equal to the square of the sum. This may look like an over simplification of the explanation, but I must confess that at a critical stage of my development, apparently my mother was frightened by an adding machine salesman and I have had a mathematical allergy ever since. For the benefit of those who may be so afflicted,

Figure 2 — The mixing control shown here is designed for the complete substitution of fuel oil for gas.

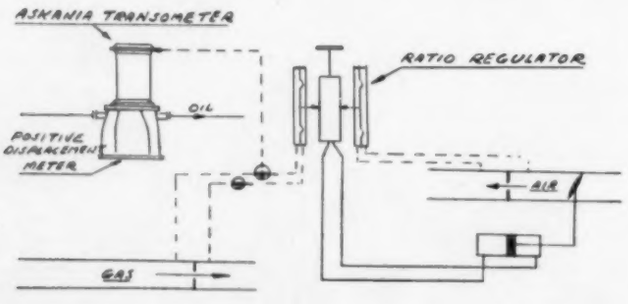
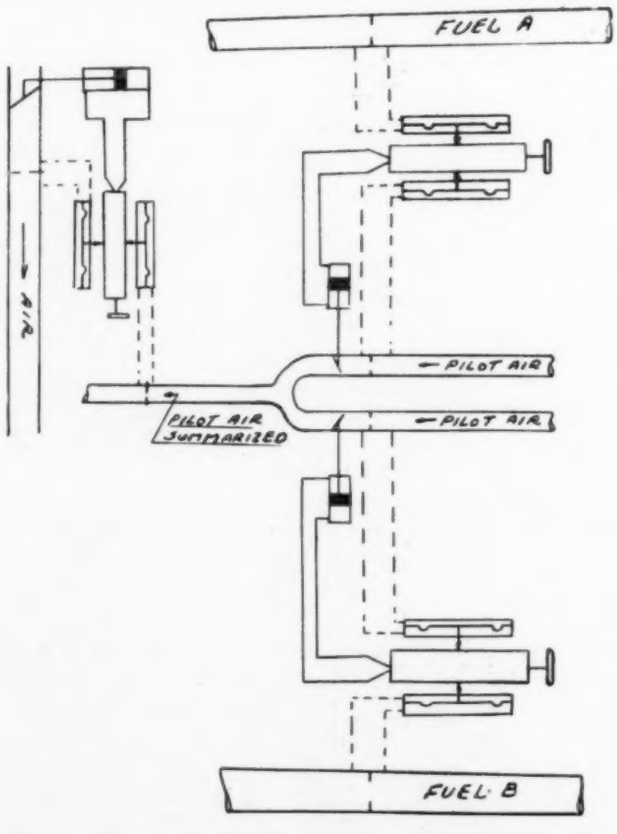


Figure 3 — This mixing control is designed to add or augment a primary fuel with an auxiliary fuel.



I am putting down this two plus two equals four explanation to get the matter straight. We have a flow of Fuel "A" of the numerical value of 2. Referring this to its orifice measurement, we find it is equal to the square root of the differential across the orifice times a constant. In the second case we have a flow of Fuel "B" which equals a constant times the square root of the differential, the numerical value of the flow being 3. If, then, we have this third orifice in the mixed line, this flow is a combination of the two flows, Q_a and Q_b which equals the square root of the differential across the third orifice, times the constant and again we can add the flows directly and come to the obvious answer of 5. Suppose, however, we attempt to add the differentials. We then find for Fuel "A" the differential represents values

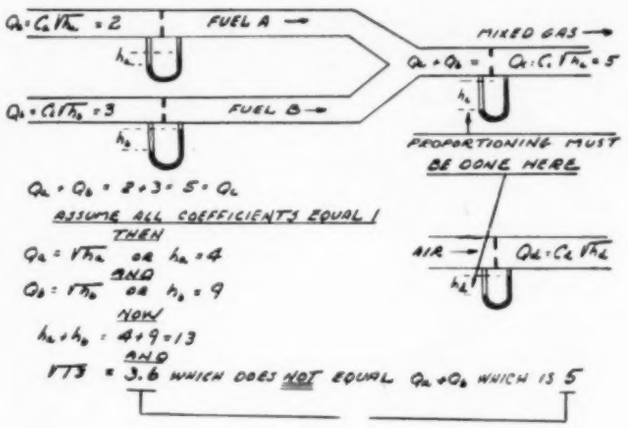


Figure 4 — It is necessary to add the flows instead of their differentials in setting up a fuel mix control.

of 4 and the differential representing the flow of Fuel "B" is 9, the sum of the differentials being 13. The flow, of course, represented by this differential would be the square root of the differential or 3.6 which does not equal the actual flow. This is a rather obvious fact, but it is, nevertheless, amazing how often it is disregarded. For instance, it is the basic reason for the error existing in the orifice measurement of pulsating flows. The method still can be used, however, over a short range, but we should be aware of the error involved. The actual fact is that in all gas mixing and combustion controls, error is involved. One factor which determines the soundness of engineering design is how well we are aware of the error and in what manner we weigh the error with the cost of reducing it.

For sometime there has been a trend in steel mill practice towards augmenting the mill gas system rather than handling the individual mill or furnace. The usual method of accomplishing this is finding a substitute for coke oven gas. Natural gas and air is an excellent one. Natural gas and blast furnace gas have had some advocates on account of possible higher safety. Propane and butane are also appearing in the picture more and more widely.

Figure 5 shows a simple arrangement for effecting this substitution or addition. Here the primary regulation adds substitute gas to the mill system in accordance with pressure requirements. Our basic mixing regulator then adds air as required. Because we are

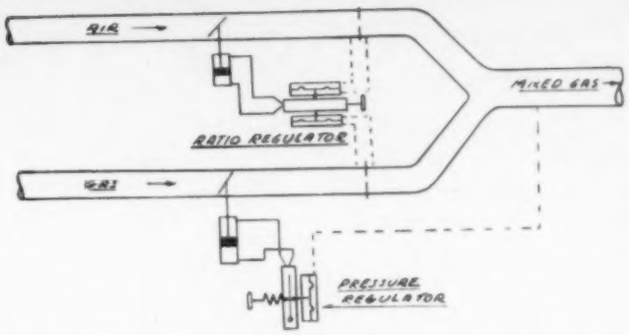
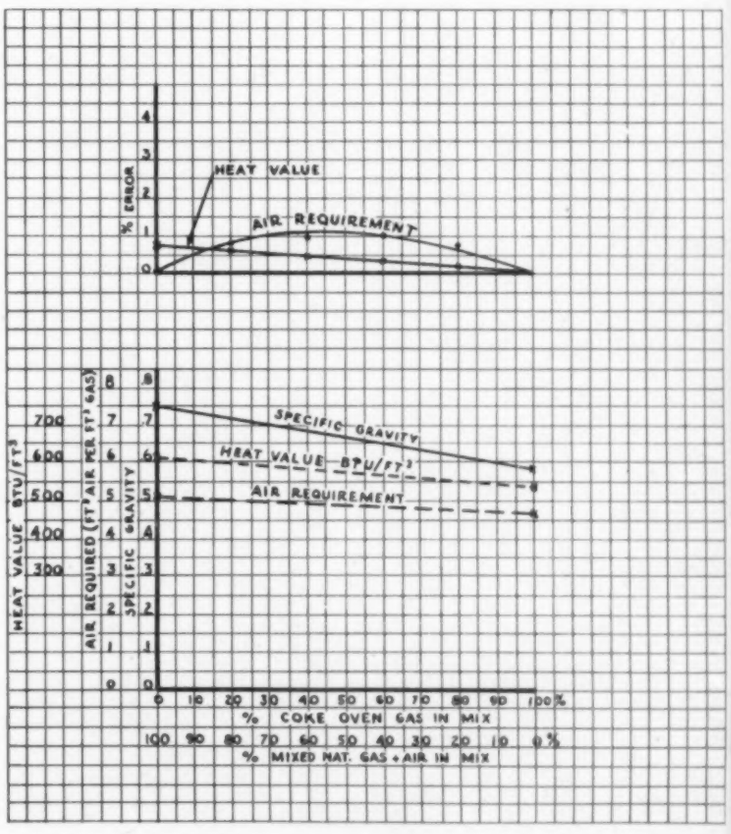


Figure 5 — In this scheme substitute gas is added to the mill system in accordance with pressure requirements.

measuring gas with orifices, this particular method of mixing is limited to cases where the percentage change demanded is not very great, possibly not more than 1 to 5. I will go into the reasons for this and what to do about it in a moment. Before that, I believe it would be of interest to discuss the matter of interchangeability of the new gas. We have seen that what is desired is to provide a new fuel which will act the same in our automatic control orifice, in our inspirating burners, and in all of our combustion equipment. In determining what mixture of new gas to supply, we are guided, therefore, by what we call air requirement of the new gas.

Figure 6 shows graphs based on these calculations. Here we are providing a mixture of natural gas and air as a complete or partial substitute for coke oven gas

Figure 6 — This chart shows the errors in air requirements and heat values when natural gas and air are used as a substitute for various percentages of coke oven gas.



and this chart shows the error involved. At 100 per cent coke oven gas, as shown on the right of the chart, we have no error in either air requirement or heat value, and we see by the chart that the maximum error in air requirement occurs at 50 per cent mixed gas.

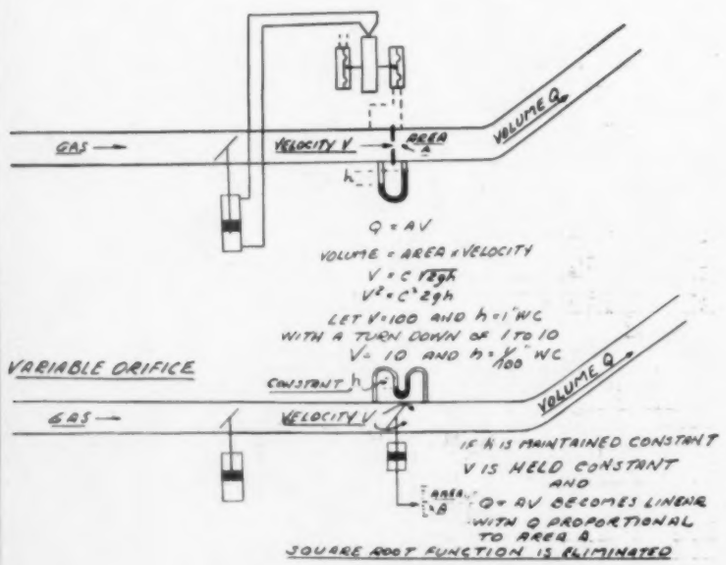
The maximum error in Btu value occurs at 100 per cent mixed gas. Both of these errors lie within reasonable operating limits. Therefore, for this particular mill, a mixed gas can be substituted which fulfills all requirements. Similar charts can be calculated for any gas or gases.

It was mentioned that the problem of wide range changes is usually encountered in mixing station installations. This means that we may find variations in mixed gas requirements as great as 50 to 1. In Figure 7, the top sketch shows what happens with fixed orifice system previously shown.

Assuming the velocity through the orifice has a value of 100 and the pressure difference created has a value of 1 in. water column, then if we reduce the flow or velocity to only one-tenth of its former value, we have reduced our pressure difference to 0.01 in. You can easily appreciate the difficulty of making a regulator or meter or any other instrument which operates on this pressure difference principle so that it will be sufficiently sensitive at 0.01 in. and at the same time sufficiently strong to take 100 times as much pressure without breaking. Some of us call this the problem of the vanishing impulse.

So what do we do about it? Many methods are used and one in particular we like. The problem is to secure a usable measurement of velocity. Therefore, instead of holding the orifice constant we vary the size of the orifice in accordance with the varying flow so as to keep the differential pressure and hence the velocity across the orifice constant (Figure 7). This means that we

Figure 7 — Varying the size of the orifice enables one to keep both the differential pressure and the velocity across the orifice constant.



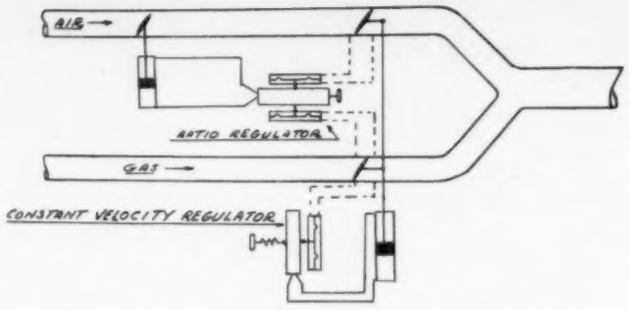
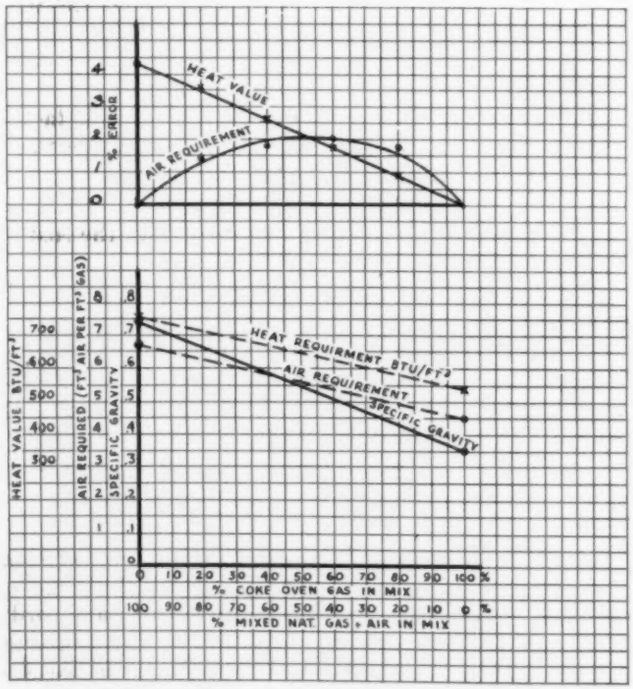


Figure 8 — The variable orifice in this control scheme is a butterfly valve.

cancel out this bothersome square root business and have a metering system which works on the principle that the flow equals the area times the velocity. With velocity constant, flow becomes proportional to the area. By measuring the area, we know the flow. This idea is not original with us and is known by the general description as an area meter. One of the first ones, if not the first, was the St. John meter built some 50 years ago for the express purpose of measuring steam, in the first central heating system installed in New York City.

The practical application of this scheme is shown in Figure 8. Here we assume that gas is being supplied to the system in a varying amount as controlled upstream by some source. This might be a pressure regulator, flow regulator, or similar apparatus. A pressure difference regulator controls a variable orifice, in this case a butterfly valve, in the gas line to maintain the velocity across the butterfly constant. The position of the butterfly valve is, therefore, a measure of gas flow. The valve is in turn mechanically connected to a similar valve in the air line. If, therefore, a constant velocity is

Figure 9 — This chart shows the error in heating value when natural gas and air are substituted in a mix with coke oven gas using an orifice meter control.



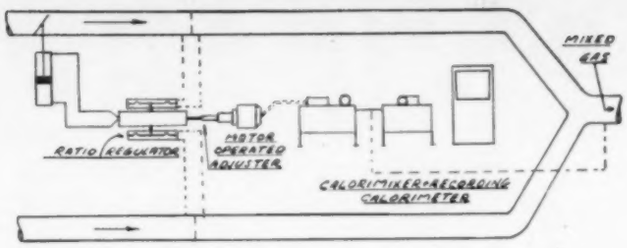
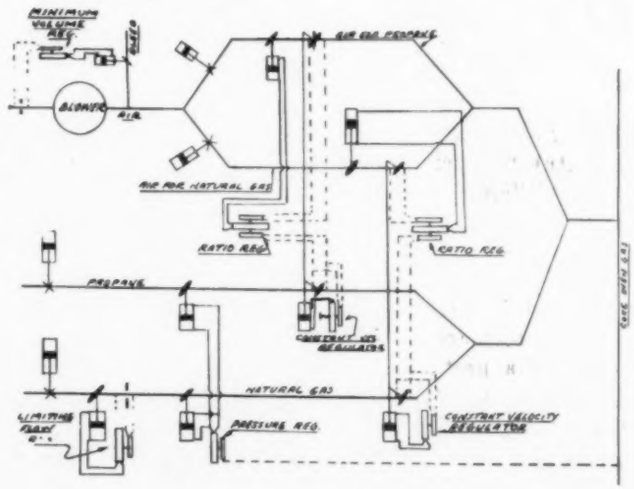


Figure 10 — In this control scheme, although the mix is done on the volumetric basis, a calorimeter controls the Btu value and adjusts it to the required amount.

maintained across this butterfly, the flow of air across the butterfly will in turn be proportioned to the flow of gas. This could be done by a regulator that is similar, but it is more convenient to go back to the basic ratio or mixing regulator and maintain equal velocities by controlling a valve upstream in the air line. It is very important to note that the constant which frequently gives so much trouble in metering systems cancels out providing suitable attention is paid to Reynolds number ranges. The two butterflies while not necessarily the same size are similar and have the same characteristics. This system may be used for very wide flow variations and can be applied to combustion control on a single furnace as well as on a complete system if desired.

Figure 9 is similar to the one previously shown, but illustrates that it is not always possible to substitute with as little error. In this case, we have a maximum error in heat value of 4 per cent. This, however, does not introduce a combustion error, but merely requires that more cubic feet of gas would have to be supplied to get the same heating effect. This error should also be taken into account in cost figures if orifice meters are used as a basis. As we have seen from some of these previous charts, a very close approximation of the substitute fuel can be made on a volumetric basis. Again it must be emphasized that errors do exist due to the changes in the composition of the primary fuels in temperature, pressure and other uncontrollable variables. Depending upon the accuracy of results required and the economic

Figure 11 — Control scheme shown here provides fuel control to a complete steel plant whose primary fuel is coke oven gas, which often is supplemented by natural gas and air.



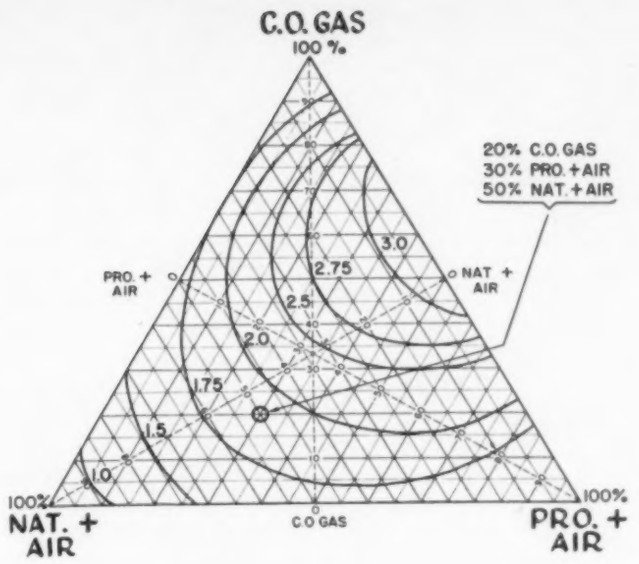


Figure 12 — This chart gives errors for various combinations of coke oven gas, natural gas, and propane.

justification of securing them, certain things can be done to counterbalance these errors.

Figure 10 illustrates a very simple and very effective method. Mixing on a volumetric basis is still done by our basic mixing regulator. This regulator is subject to constant readjustment by a calormixer which is measuring the Btu value of the mixed gas. This method has been very popular in the public utilities and in many steel mills who are supplying gas to other consumers on a Btu basis.

Figure 11 looks a little bit more complicated than the other diagrams, but it is used to show what can be done if necessary to provide continuous uninterrupted flow of fuel to a complete plant, in this case, a steel mill. Here we have a case where the primary fuel is coke oven gas. It is frequently in short supply and is supplemented with a mixture of natural gas and air. To further complicate the picture, however, in certain cases where natural gas itself becomes short, it is necessary to in turn supplement the natural gas with propane. We, therefore, set up the first substitute fuel as natural gas and have an arrangement whereby subject to pressure variations in the coke oven gas line, the natural gas comes on automatically and in whatever amount necessary.

According to instructions received from the natural gas supplier, a limiting flow regulator is ready to limit the natural gas supply as required. If this occurs, it is indicated to the mixing station by the natural gas control cylinder going to the wide open position whereupon a second control cylinder, in series with the first, opens up the propane line and adds propane in whatever quantity required to make up the natural gas deficiency. In both cases the proper amount of air for natural gas and for propane are automatically supplied. The system has the necessary interlocks and safety measures, though not shown in the illustration, to assure that all operations occur in their proper sequence.

In Figure 12 is shown a composite chart indicating the error for any combination of coke oven gas, natural gas and propane.

ELECTRICAL HEATING

. . . . electrically heated protective atmosphere furnaces, resistance furnaces, and induction furnaces all offer interesting possibilities for continuous processing in various departments of the steel plant . . . .

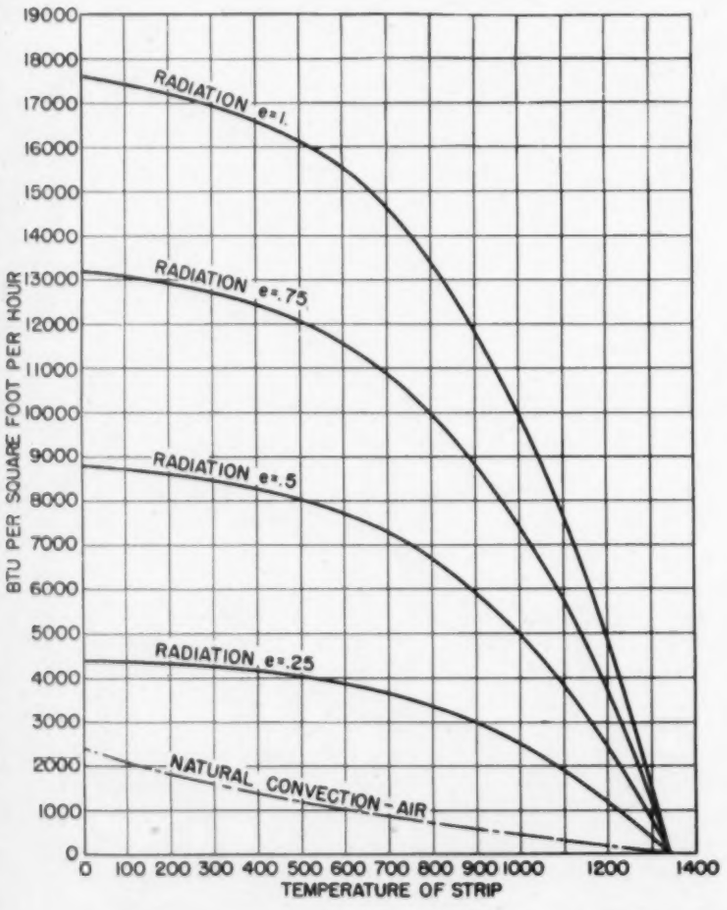
▲ SINCE the development of the continuous strip mill there has been a decided interest in the heating of continuously moving strips of steel. Such heating is for the purpose of heat treating the steel or processing it as in the flowing of electrolytically deposited tin.

Continuous heating is inherently a short time process, hence it ties up only a relatively small amount of material. Also, if properly controlled, the uniformity of results are very good. In addition, there are processes, such as normalizing and the heat treatment of special steels for which continuous treatment has decided metallurgical advantages.

The three basic methods of electrically heating a continuously moving steel strip are:

1. Furnace heating in which one or more steel strips are moving continuously through an electrically heated furnace. Such furnaces are usually filled with a protective atmosphere to prevent oxidation and in some cases decarburization of the steel.
2. Resistance heating in which the strip is heated by an electric current passed longitudinally through the strip, the current being introduced into the strip by means of contact rolls.
3. Induction heating in which the strip is passed through one or more coils carrying a high frequency current which in turn induces high frequency currents in the steel, causing it to heat.

Figure 1 — Calculated rate of heat transfer to a steel strip of varying surface emissivity. Curves show increasing importance of convection heating as surface emissivity decreases. Total rate of heat transfer is the sum of the radiation and convection rates.



Presented before AISE Annual Convention, Pittsburgh, Pennsylvania, September 23, 1947

FURNACE HEATING

Furnace heating is the most commonly used of the three methods. It is a desirable method when the strip is to be heated to relatively high temperatures and when the strip must be held at the high temperature for a definite time; also for applications where regulated cooling is required.

The principal factors which influence the type, size, and features of a strip heating furnace are as follows:

1. *Rate of heat transfer*—The rate of heat transfer from the furnace to the moving strip is of prime importance in determining the physical size and arrangement of the furnace. Heat transfer is obtained by radiation and convection. These factors are so important that it is desirable to consider them in some detail.

The rate at which heat is transferred by radiant energy from the furnace to the strip is approximately:

$$H_r = 0.174e\left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right]$$

Where H_r = Btu per sq ft of strip surface per hour
e = Total emissivity of the strip surface
T_1 = Furnace temperature in degrees F, absolute—(F + 460)
T_2 = Strip temperature in degrees F, absolute—(F + 460)

Figure 1 is a series of curves showing the rate of heat transfer by radiation from a furnace at 1340 F (1800 F absolute) to steel strip at different temperatures and having different surface emissivities. A similar set of curves for other furnace temperatures can be calculated.

The rate of heat transfer to the strip by natural convection currents of hot air or protective atmosphere within the furnace depends upon a number of factors some of which are difficult to evaluate. Since most furnaces use a protective atmosphere consisting largely of nitrogen, we can assume that the convection heat transfer of such an atmosphere is the same as for air. With this assumption, the heat transfer by natural convection is approximately $H_c = 0.296\ (t)^{1.25}$.

OF STEEL STRIP FOR CONTINUOUS PROCESSING

By A. R. RYAN and
F. E. ACKLEY
General Electric Company
Schenectady, New York

Where H_c = Btu per sq ft of strip area per hour
t = Temperature gradient between the strip and furnace in degrees F at a given instant

The bottom curve Figure 1 shows the calculated rate of heat transfer by natural convection to strip at different temperatures assuming a furnace temperature of 1340 F. Similar curves can be calculated for other furnace temperatures. If the protective atmosphere in the furnace consists largely of hydrogen, which has both a high thermal conductivity and a high specific heat, the heat transferred by convection will be higher than that given by the above equation, a fact which has been verified by test.

Figure 1 shows that when the surface emissivity of the steel strip is high, most of the heat transfer is by means of radiant heat but when the emissivity of the steel is low, the heat transferred by convection is important in determining the rate at which a strip of steel will heat. If a family of curves, similar to Figure 1 but for higher and lower furnace temperatures, were drawn, it would be found that the lower the furnace temperature, the more important would convection heating become.

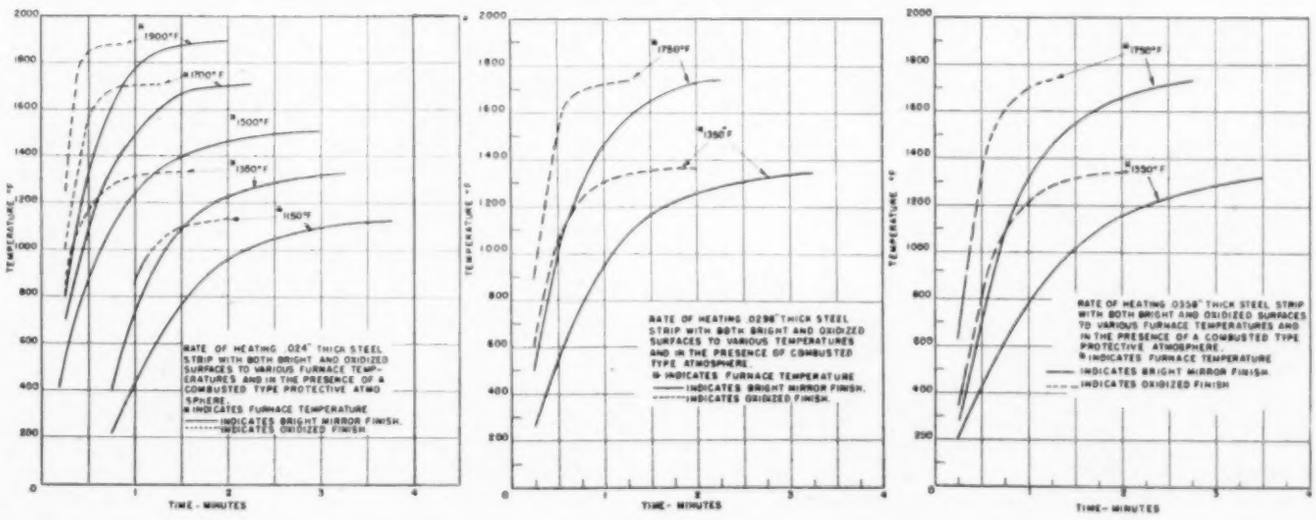
Curves such as Figure 1 are helpful in realizing the relative importance of radiation and convection heating but they do not enable one to determine directly the rate at which a strip of steel will heat under a given set of conditions. Due to the varying temperature gradient and the variation of specific heat and emissivity with temperature, the rate of heating of a strip cannot be calculated directly. However, with curves similar to those in Figure 1 and a knowledge of the variation of specific heat with temperature and the approximate surface emissivity, a rate of heating curve may be calculated with a step by step method. The procedure is tedious and since the emissivity varies widely with surface condition there is possibility of error.

A practical method of determining the time to heat a given strip is by actual test with two one-foot-square sections of strip, each one-half the desired strip thickness, sandwiched together with a light gage thermocouple placed between the strips at their centers. The assembly of strips being placed into a medium sized furnace operating slightly above the desired strip temperature and provided with an atmosphere of the type to be used in the production strip treating furnace. An automatic temperature recorder should be used to record the temperature at the center of the strip.

Figures 2-A, 2-B, and 2-C show the results of such tests. These curves show that:

1. Strips heat to high temperatures more quickly than to low temperatures.
2. Strips with oxidized surfaces heat more quickly than strips with bright surfaces.
3. For a given temperature and surface condition,

Figure 2 — Rate of heating a strip is inversely proportional to its thickness and strip heats to high temperature more quickly than to low temperatures.


TEMPERATURE °F
TIME - MINUTES
1900°F
1700°F
1500°F
1350°F
1150°F
RATE OF HEATING .024" THICK STEEL STRIP WITH BOTH BRIGHT AND OXIDIZED SURFACES TO VARIOUS FURNACE TEMPERATURES AND IN THE PRESENCE OF A COMBUSTED TYPE PROTECTIVE ATMOSPHERE.
INDICATES FURNACE TEMPERATURE
INDICATES BRIGHT MIRROR FINISH.
INDICATES OXIDIZED FINISH.
1750°F
1350°F
RATE OF HEATING .0298" THICK STEEL STRIP WITH BOTH BRIGHT AND OXIDIZED SURFACES TO VARIOUS TEMPERATURES AND IN THE PRESENCE OF COMBUSTED TYPE ATMOSPHERE.
INDICATES FURNACE TEMPERATURE
INDICATES BRIGHT MIRROR FINISH.
INDICATES OXIDIZED FINISH.
1750°F
1550°F
RATE OF HEATING .0338" THICK STEEL STRIP WITH BOTH BRIGHT AND OXIDIZED SURFACES TO VARIOUS FURNACE TEMPERATURES AND IN THE PRESENCE OF A COMBUSTED TYPE PROTECTIVE ATMOSPHERE.
INDICATES FURNACE TEMPERATURE
INDICATES BRIGHT MIRROR FINISH.
INDICATES OXIDIZED FINISH

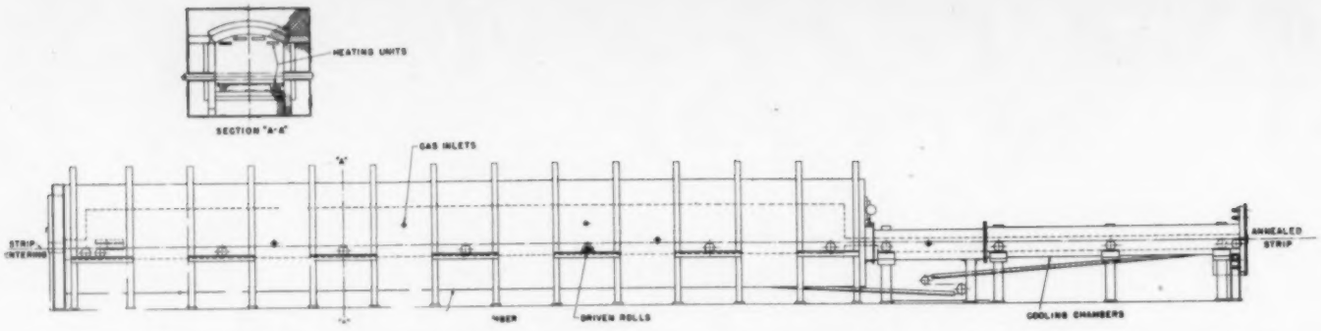


Figure 3 — This roller hearth furnace was designed for the heat treatment of electrical steels. Widths up to 36 in. and thicknesses from 0.014 to 0.025 can be handled.

the rate of heating of a strip is inversely proportional to its thickness.

Calculations on some of the curve data show that the emissivity averaged 0.227 for the bright strip and 0.674 for the oxidized strip. These values agree well with published values of emissivity.

2. *Maximum strip temperature*—The maximum temperature to which the strip is to be heated is important since it not only determines the rate of heating but also the tensile strength of the hot strip, the strength of alloy structural parts in the furnace, the kind and quantity of refractory and insulating materials used, the effect of protective atmosphere on the strip, the total power required and to some extent the rate of cooling the hot strip.

3. *Time at temperature*—The time that the strip must be held at the desired elevated temperature is important since the length of the heating chamber must be such as to enclose the strip when it is moving at the highest desired rate of speed.

4. *Rate and degree of cooling*—The rate and degree of cooling of the strip are important since they determine not only the length of the cooling chamber but also its construction. Some retarded cooling cycles necessitate the use of cooling chambers equipped with both heating units and cooling tubes both with automatic control.

5. *Strip thickness*—The thickness of the strip governs both the rate of heating and the method of handling the strip in the furnace. Very thick strip is difficult to bend around supporting rolls and may necessitate unusually heavy rolls and a powerful drive system. Also the strip thickness (and its metallographic structure) may make it impractical to bend the strip in one direction over one roll and in a reverse direction over a following roll.

6. *Number of strips*—The number of strips to be heated simultaneously may govern the method of supporting the strips in the furnace and the number of unreeling, reeling and looper devices that must be used with the furnace.

7. *Type of protective atmosphere*—The type of protective atmosphere required affects the furnace design to some extent. A non-combustible or air atmosphere furnace need not be as well sealed nor operated with the same precautions as if it were to use a highly combustible atmosphere such as hydrogen. A furnace utilizing an atmosphere high in hydrogen must be well sealed and also very well insulated to compensate for the greater heat conductivity of the hydrogen which infiltrates the brickwork.

8. *Desired metallurgical or process results*—The metallurgical or process results desired naturally have an important bearing on the type of furnace and its design details. For example, steels which tend to build up projections on strip supporting rolls may require a furnace design that eliminates contact with rolls when the strip is at high temperature.

9. *Floor space*—The floor space available may also influence the furnace design to a great extent. Strip furnaces tend to be very long and in some cases they have been built vertically to save floor space.

A brief discussion of several types of furnaces will serve to illustrate the development of continuous strip heating furnaces to meet varying requirements.

ROLLER HEARTH FURNACES

Figure 3 shows a single deck, roller hearth furnace designed for the heat treatment of electrical steels, 0.014 to 0.025 in. thick and up to 36 in. wide, at temperatures up to 1700 F. This particular steel permitted no sharp bends, required a considerable holding time at temperature and a slow cool through a narrow temperature range followed by a quick cool.

The furnace has a capacity of 2000 pounds per hour and is rated 450 kw; has a 40-ft long heating chamber followed by a 6-ft long heat insulated cooling chamber and a 14-ft long water jacketed chamber. Protective atmosphere is used to limit oxidation of the steel. A power consumption of about 220 kwhr per ton is obtained at 1475 F.

Figure 4 shows a double deck roller hearth furnace (two rows of strips, one row above the other) designed for the same heat treating process as the furnace of Figure 3. The furnace is rated 529 kw and has a 48-ft long heating chamber followed by a 12-ft long chamber for retarded cooling and a 30-ft long water-jacketed chamber for accelerated cooling. When treating 3500 pounds per hour at 1475 F the power consumption is about 205 kwhr per ton.

In both of the above furnaces, the strip is held at operating temperature for a considerable time, hence the economy is not as good as if it were merely necessary to heat the strip and start cooling it immediately. It will be noted that a very appreciable increase in output was obtained by means of the double deck roller

hearth arrangement without a proportional increase in furnace size.

TOWER TYPE FURNACE

Figure 5 shows a tower type furnace with a horizontal cooling chamber. The equipment was designed for annealing tin plate material 0.01 to 0.015 in. thick and 20 in. wide, at temperatures up to 1800 F. Such strip can readily be bent around rolls, requires no holding time at temperature and does not require a carefully regulated cooling.

The furnace is rated 375 kw and has a heating chamber 48 ft high which will accommodate 107 ft of strip in a single strand. The horizontal water-jacketed cooling chamber is 58 ft long.

The furnace accommodates two strips, running parallel to each other through the furnace on two independently driven sets of rolls. The incoming section of each strip passes the hot outgoing section of the same strip so that considerable heat exchange takes place. At an output of 4000 pounds per hour, the power consumption is approximately 150 kwhr per ton. Protective atmosphere is used to prevent oxidation of the strip.

CATENARY TYPE FURNACE

Figure 6 shows a catenary type furnace in which the strip is supported by two driven rolls located where both rolls and strip are at temperatures considerably lower than maximum strip temperature. This type of furnace can thus be designed for high temperatures. The furnace may be used for one wide strip or a number of strips. It should be particularly suitable for bright normalizing of wide strip and for steels which tend to build projections on the rolls. Although not shown in Figure 6 it would be entirely practical to double deck this type of furnace to obtain increased output. In addition, a horizontal roller hearth chamber could be placed in front of the catenary chamber to preheat the strip and thereby increase the output or reduce the size of the catenary span for very high temperature operation.

The particular furnace shown in Figure 6 is rated 462 kw and has a heating chamber 6 ft wide, 31 ft long, with a 42-ft catenary span. The furnace is designed for operation at 1950 F. The cooling chamber is only 57 ft long since for the particular application involved it was not necessary to cool the steel much below oxidizing temperature.

The following formulas and Figure 7 are of value in determinng the feasibility of a catenary type furnace for a given strip and temperature.

$$L = l + \frac{8S^2}{3x1}$$

Where L = Feet of strip in catenary (approximate)
l = Feet spacing between horizontal catenary supports
S = Sag of catenary in feet

$$P_{max} = \frac{wl.}{8S}\sqrt{l^2 + .16S^2}$$

Where P_{max} = Maximum pounds pull on strip; which occurs at points of support
w = Weight of strip in pounds per foot of length
l = Horizontal spacing of catenary supports in feet
S = Sag of catenary in feet

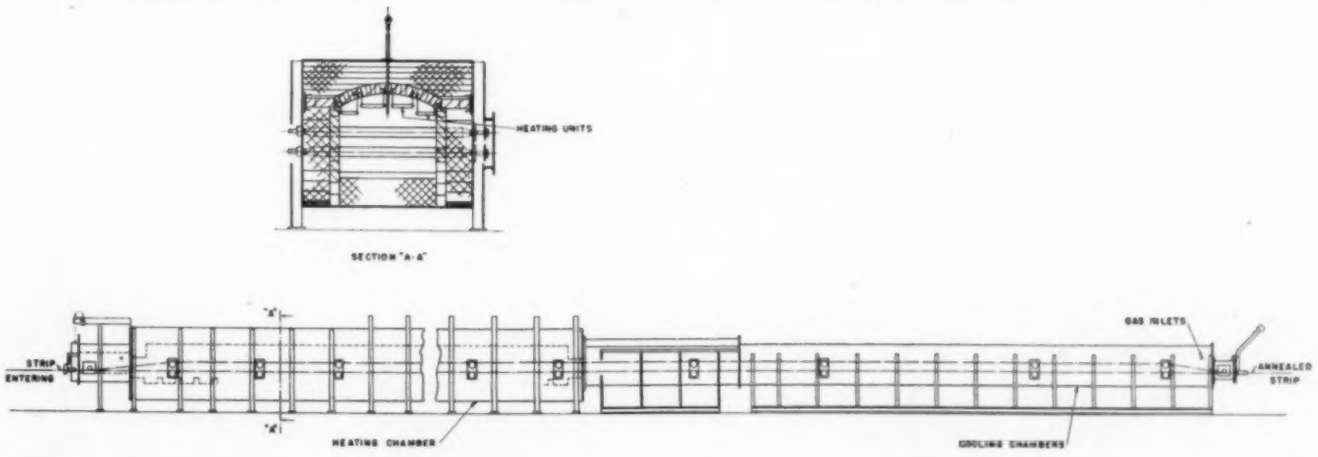
Figure 7 shows the approximate ultimate strength of steel at various temperatures. A factor of safety of 10 to 15 should be used so as to make allowance for unusual stresses in starting up or in changing speeds.

$$T_u = \frac{f\,P_{max}}{A}$$

Where T_u = Ultimate tension in psi (Figure 7)
P_{max} = Maximum pounds pull on strip
A = Cross section area of strip in square inches
f = Factor of safety

Figure 8 shows a proposed tower type, multiple pass furnace arranged to handle a single strip at high speeds. The furnace uses a protective atmosphere and is rated 1780 kw; has an effective heating chamber length of 140 ft followed by a 120-ft chamber for retarded cooling and a 360-ft water-cooled chamber for rapid cooling.

Figure 4 — This double deck roller hearth furnace, which is designed for the same process as the furnace in Figure 3, has a power consumption of 205 kwhr per ton in treating 3500 lb of steel per hour.



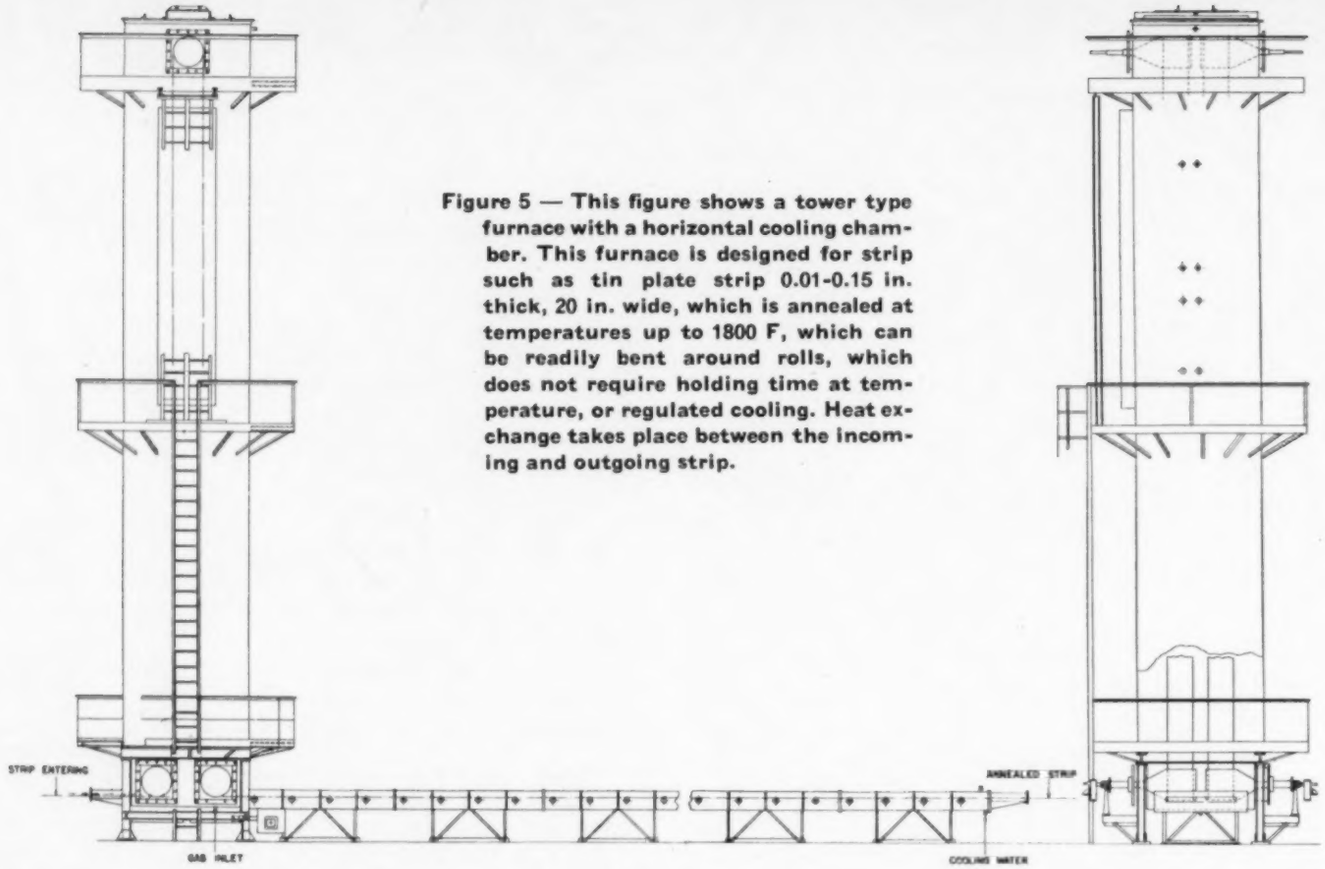


Figure 5 — This figure shows a tower type furnace with a horizontal cooling chamber. This furnace is designed for strip such as tin plate strip 0.01-0.15 in. thick, 20 in. wide, which is annealed at temperatures up to 1800 F, which can be readily bent around rolls, which does not require holding time at temperature, or regulated cooling. Heat exchange takes place between the incoming and outgoing strip.

This furnace is capable of treating a single 37 in. wide, 0.02 in. thick strip heated to 1380 F at the rate of 20,000 pounds per hour with a power consumption of about 130 kwhr per ton.

This furnace has the advantage of large output in a single unit with comparatively small floor space required and with only one unreeling, reeling and looper mechanism. Because of the large number of reverse bends required, the furnace is limited to relatively thin strip.

CONTROL OF STRIP HEATING FURNACES

Due to the high ratio of a strip's surface area to its weight, the temperature of the strip is highly sensitive to changes in furnace temperature. It is therefore necessary to use control methods which will give the required accuracy of strip temperature.

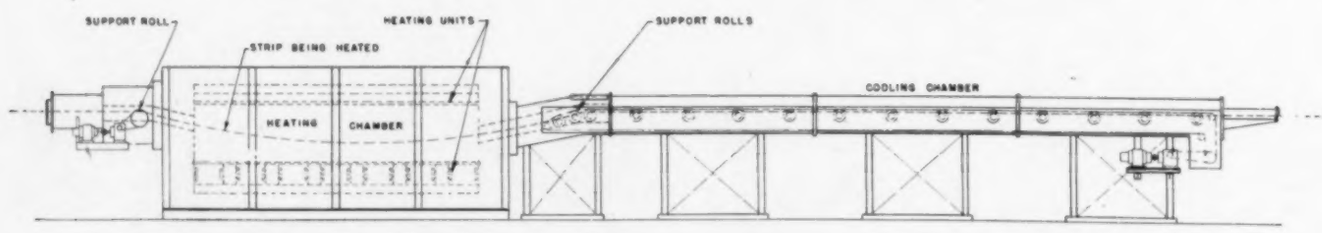
All of the furnaces previously described are divided into a number of separately controlled heating zones through which the strip travels as it passes through the furnace. The electrical rating of each zone is proportioned to the amount of heat the strip can absorb while it passes through the given zone.

The amount of power applied to a zone is automatically regulated according to temperature requirements by means of an automatic temperature control instrument connected to a thermocouple located in that furnace zone. Two methods of regulating the power input to the furnace heating units are employed, namely On-Off control and a saturable core reactor system.

On-Off is a system in which the control instrument causes a magnetic contactor to remove all power from the heating units when the temperature is slightly above normal and to apply full power when the temperature is slightly below normal. The spread between On and Off is so small that the change in furnace temperature is usually negligible.

On-Off control is usually satisfactory for controlling the furnace zones where the strip enters, for the heat requirements are such that under normal production

Figure 6 — Strip metal is continuously annealed in this catenary type furnace.



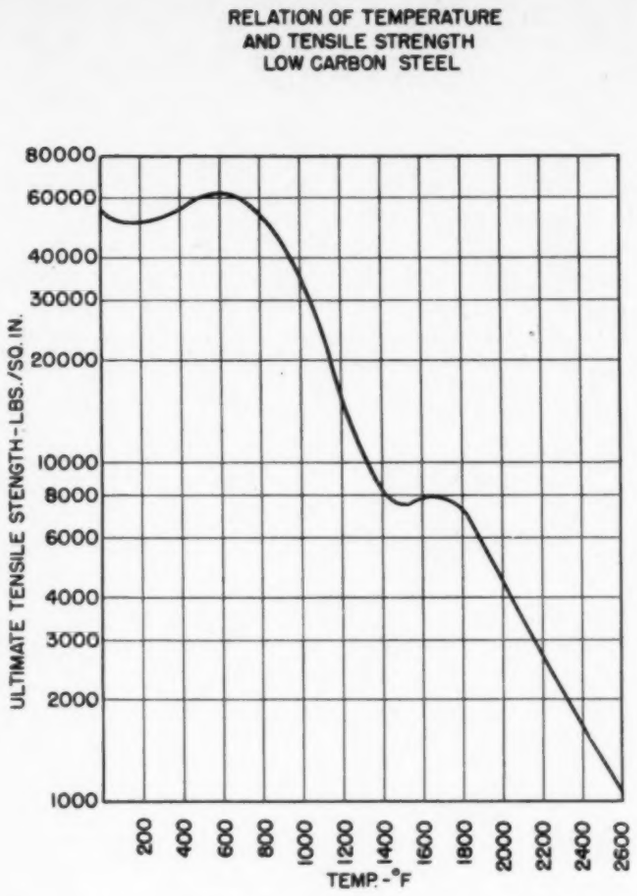


Figure 7 — The curve gives the tensile strength of low carbon steel at various temperatures.

the slight temperature variations have little or no effect on the heat treatment of the strip. Such a control is also usually satisfactory for a heavy gage strip traveling at low speed through the furnace.

The reactor system automatically varies the voltage applied to the furnace heating units so that power is applied continuously but is accurately and quickly regulated to meet the temperature requirements. This system utilizes one or more saturable core reactors connected in series with the furnace heating units and the power supply. The saturable core reactor is a variable impedance which, when varied by means of a small direct current, changes its own a-c voltage drop and hence the voltage applied to the furnace heating unit with which it is in series.

The direct current for saturating the reactor is obtained from an automatic rectifier controlled by a small potentiometer in the temperature control instrument.

This unit provides greater accuracy of temperature control, elimination of a fluctuating temperature gradient between heating units and strip, and in many cases a longer heating unit life.

COOLING

To conclude this discussion of strip heating furnaces, it should be noted that little mention of rates of cooling and cooling chamber design has been made. This is because the prime subject is the heating of strip; also because the subject of cooling, although similar to heating, is made more complex by the varied requirements for retarded or regulated cooling rates.

RESISTANCE HEATING

Resistance heating provides a means of rapidly heating thin strips of steel and quenching them on a rising maximum temperature. It is inherently a continuous process involving a single strip. Figure 9 shows a typical resistance heating arrangement using polished rolls as a means of making contact with the strip. The process has good economic possibilities for low temperature strip heating applications and also for high temperature applications when it is necessary to quench the hot strip before it comes into contact with the outgoing contact roll. If the maximum strip temperature is to be above the scaling temperature of steel, it would probably be

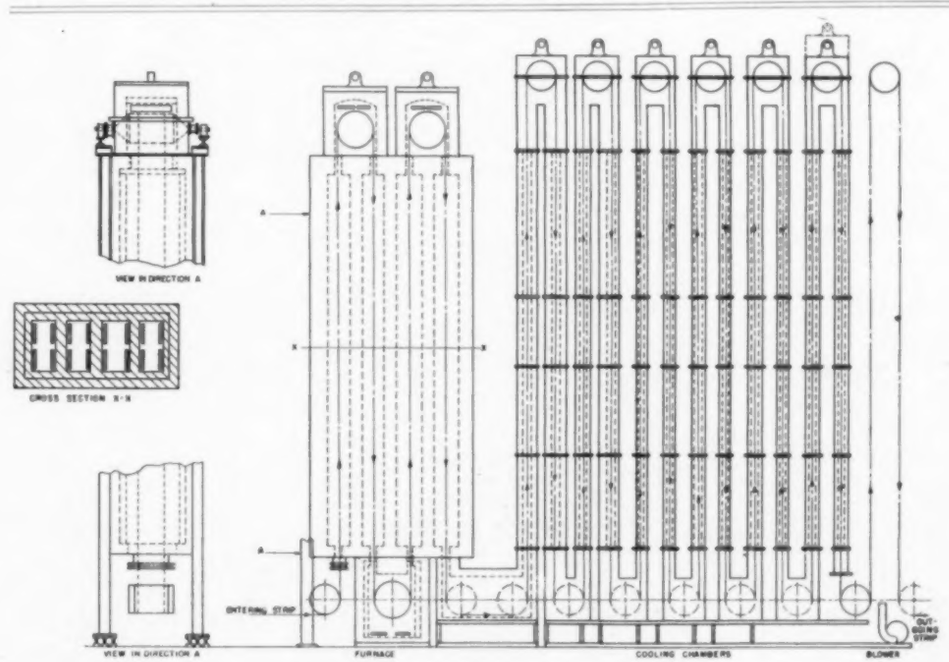


Figure 8 — This multiple pass tower type furnace is rated at 1780 kw and uses a protective atmosphere. This furnace is capable of treating a single 37 in. x 0.02 in. strip heated to 1380 F at a rate of 10 ton per hr. The furnace thus gives large output in a comparatively small unit.

necessary to use a protective atmosphere around the hot strip so as to prevent scale formation which might cause sparking between strip and roll and hence mar the strip surface.

Resistance heating has some inherent disadvantages. It is basically a high power, single phase load which is often objectionable. The thickness of strip which can be handled is limited due to the fact that there is a limit to the amperes per inch of strip width which can be transmitted to the strip without sparking. This means that for a given width of strip there is a maximum allowable current irrespective of strip thickness so that the thicker gages of strip will heat more slowly than thinner gages. In addition, the usual arrangement of rolls requires several reverse bends in the strip that may be objectionable.

Both rolls and strip must be kept clean in order to insure a smooth flow of current from roll to strip; so that sparking does not occur and mar the strip.

Due to the difficulty of making spark proof contact between hot strip and the outgoing contact roll, resistance heating does not seem practical for applications requiring regulated or slow cooling. Also, since the strip temperature continues to increase as the strip approaches the outgoing contact, the method is not suitable for applications requiring holding the strip at temperature.

The fact that the strip itself carries current and voltage makes the method hazardous and uneconomical unless the unreeling and reeling mechanisms are grounded and a ground current choke employed to limit ground current to two or three per cent of the total current supplied to the equipment.

The design of a resistance heating equipment poses the interesting problem of how fast will a strip heat with a given current density, what voltage is required to produce the current and what production in pounds per hour can be obtained from the equipment.

Due to the variation of both specific heat and specific resistance with temperature, it is difficult to determine a single expression by means of which the time required to heat a strip may be calculated directly. However, if it is assumed that a heated, automatically regulated, heat insulated chamber surrounds the strip (see Figure 9), and that the chamber supplies all heat losses so that all energy generated in the strip is used in heating it, it is possible to calculate with a step by step method the time required to heat, the voltage and current required, and the temperature distribution along the strip.

To illustrate the problem involved, assume that it is desired to heat 6000 pounds per hour of 12 in. wide by 0.02 in. thick strip to 1100 F and water quench it. Assume that 200 amperes per inch of strip width can be safely transmitted to the strip without sparking.

The strip weight $= 12 \times 12 \times .02 \times .283 = 0.815$ lb per sq ft.

$$\text{The strip speed} = \frac{6000}{0.815 \times 3600} = 2.04 \text{ fps}$$

If one determines the power required to heat a square foot of the strip for a number of equal temperature increments, the average electrical resistance of the square foot of strip for the temperature increments and the power dissipated in the strip at each temperature by the passage of 2400 amperes of current, it is possible to obtain the total time required to heat the strip and the required spacing of contact rolls. Table I shows the steps involved in such an approximate method of calculation. It will be noted that the kwhr calculated with the volts and amperes corresponds very closely to the kwhr determined by calculating the power required using the hourly production, the average specific heat and the temperature rise of the steel.

The data of Table I assumes that all current supplied to the equipment is used for heating the strip. For safety reasons, it is very desirable to be able to ground both the unreeling and reeling equipment. In order to do this and yet not short circuit the power supply, it is necessary to surround one section of the strip between a contact roll and ground with a laminated silicon steel core which serves as a choke and holds the ground current to about 3 per cent of the total current.

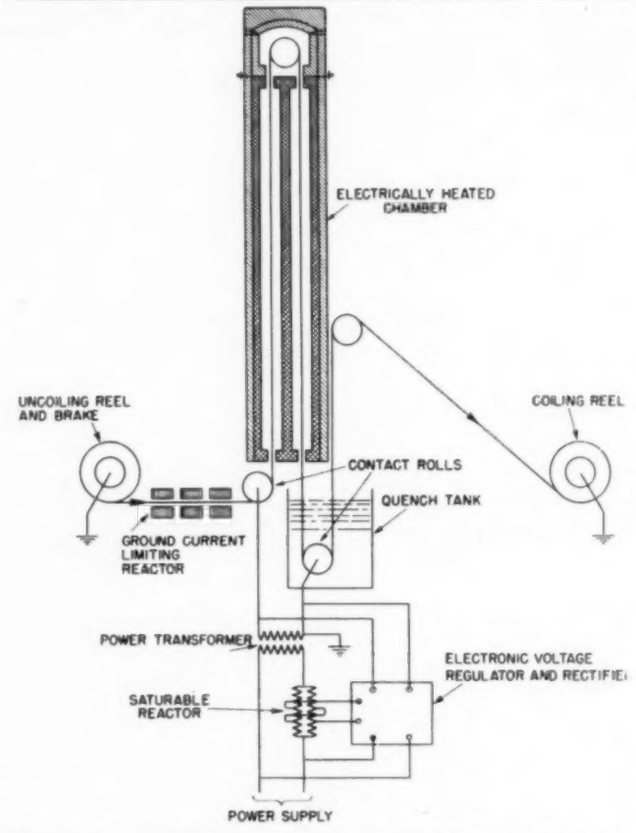


Figure 9 — Polished rolls make contact with the strip in this resistance furnace.

The total current supplied to the contact rolls is therefore:

$$I_t = 1.031I = 1.031 \times 2400 = 2475 \text{ amperes.}$$

Where I_t = The total current

I = Useful current in the strip

Total power supplied to contact rolls $= \frac{2475 \times 105}{1000} = 260$ kwhr

Power supplied to compensate for heat loss of insulated chamber ..... 20 kwhr

Total estimated power consumption ..... 280 kwhr

OR $\frac{280}{3} = 93$ kwhr per ton

Since the 2400 amperes and 105 volts determined in Table I are supposedly actual operating values, the equipment supplying the power should have somewhat greater capacity in order to provide margin for control purposes and to compensate for the power factor of the strip circuit. Also other strip sizes which are to be treated should be checked to see if they fall within the range of current and voltage determined in Table I. Assuming that the 2400 amperes and the 105 volts are maximum normal values, it would seem logical to choose a transformer having an output rating of 2500 amperes at 120 volts or 300 kva.

Resistance heating demands a variable voltage type of control so that there will be a continuous but accurately regulated flow of current through the strip. One method of control is to use a saturable core reactor connected in series with the primary of the power transformer and having the saturable core reactor automatically regulated by means of an electronic type rectifier and automatic current regulator. The regulator would be equipped with a manual control knob so that any desired current could be chosen after which the current regulator would take over control to hold that current irrespective of normal changes in line voltage.

Another method of supplying automatically regulated voltage to the strip is to utilize a single phase a-c generator driven by a three-phase motor. The voltage output of the generator being automatically controlled by an electronic current sensitive device operating on the field of the generator exciter. This method of control has the advantage of supplying the required single phase power but drawing balanced three-phase power from the supply lines. This method is also well suited to applications where the size of the strip treated may vary over a wide range.

The foregoing outlines the general problems involved in designing and operating a resistance type strip heating equipment. The method has definite advantages for certain types of heating operations.

INDUCTION HEATING

Induction heating is the heating by I^2R loss of conducting materials, such as ferrous and non-ferrous metals, when they are placed in a varying magnetic field. The magnetic field induces a current in the material by a process similar to that which occurs in a transformer. In this analogy, the transformer primary is a multiturn inductor coil surrounding a given length of the strip; the transformer secondary is that portion of the strip which is within the coil. The strip may thus be thought of as constituting a single short-circuited turn, since the induced current travels in a closed path around its cross-sectional perimeter. The objective is to confine this path to a surface layer; there is substantially one reason for using high frequency and this is that the effective depth of this layer is decreased (and thus the effective resistance increased) to the point where the strip cannot carry the induced current without becoming heated. This is commonly called "skin effect." The frequencies employed to get a skin effect are high enough so that this can be an air-core transformer, thus greatly simplifying the arrangement.

Induction heating offers some attractive advantages, among which are:

1. Rapid heating. Full heat is available in the strip as soon as power is connected to the inductor coil. No warm-up time, as with a furnace, is required.
2. Ease of control. Heat can be readily and automatically adjusted to varying line speeds; can be instantly removed in the event of a line shutdown, thus preventing the over-heating of any material which might cause scrap, weakened strip, etc.
3. Saving of space in the line. Since the rate of heating by induction is extremely fast, the required heat can be put into the strip in a relatively short space.
4. No physical contact is required between electrical circuit and strip; eliminating the possibility of arcing at contact rolls, especially at the higher line speeds and power levels.
5. Strip is kept at ground potential.
6. No limitation on maximum thickness of strip that may be heated.

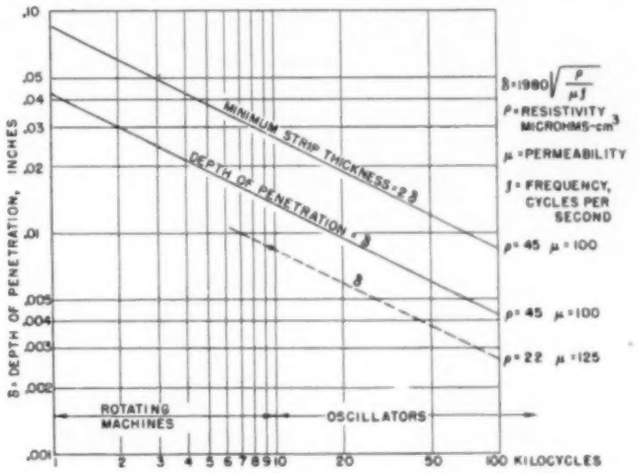


Figure 10 — A logarithmic curve shows how the depth of penetration varies with the frequency in induction heating.

THEORY

Depth of penetration is a term that is frequently encountered when considering induction heating. At the risk of repeating available, and perhaps generally appreciated information, the authors consider it warranted to include a brief discussion of this phenomenon in order that the inductive heating of strip shall be clearly understood.

Approximate depth of current penetration may be calculated from the expression:

$$\delta = 1980\sqrt{\frac{\rho}{\mu f}}$$

where δ = depth of penetration in inches
ρ = resistivity of strip, microhms per cu cm
μ = permeability of strip
f = frequency in cycles per second

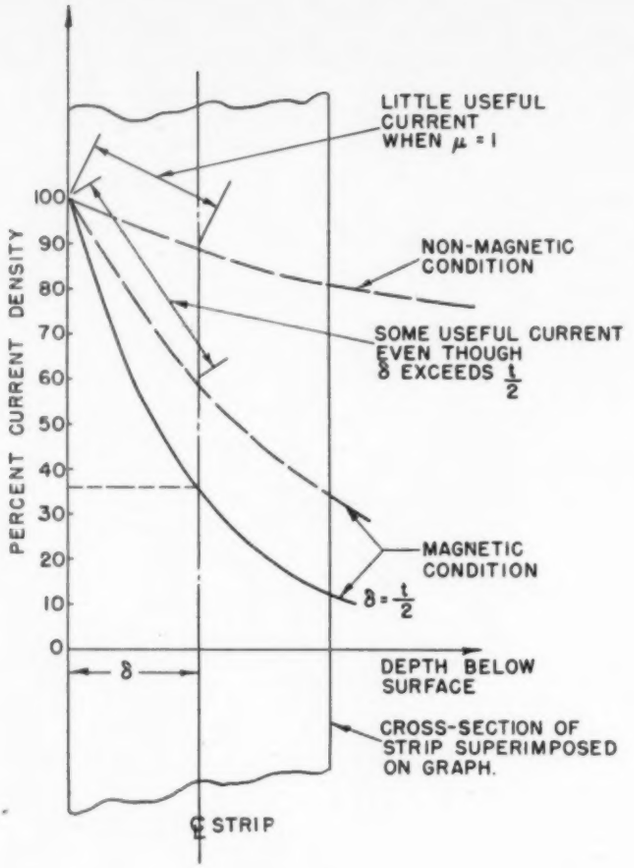


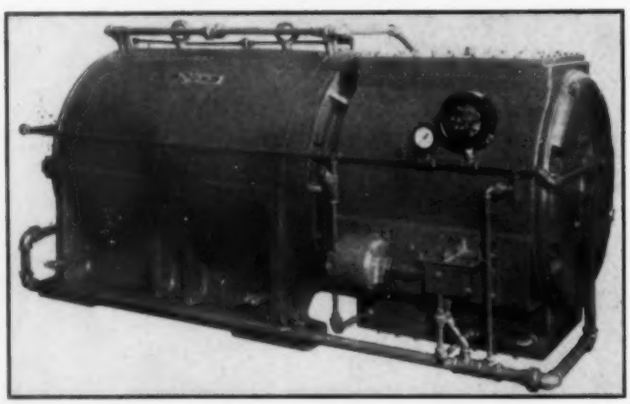
Figure 11 — If metal is being heated by induction at the critical temperature at which the strip becomes non-magnetic, it is possible to reach a point where radiation loss equals power input.

ρ increases with temperature and the first observation to be made from this formula is that, for a given frequency, as the strip becomes hotter the depth of penetration increases and hence the heating is less effective. Thus, the temperature to be attained is an important consideration.

μ is a complex function having an average value of about 100 (although as noted later may be varied considerably to suit the particular conditions).

Knowing the desired maximum temperature, a value

Figure 12 — This 2-unit, 2-bearing frequency-changer set may be obtained in capacities up to 250 kw.



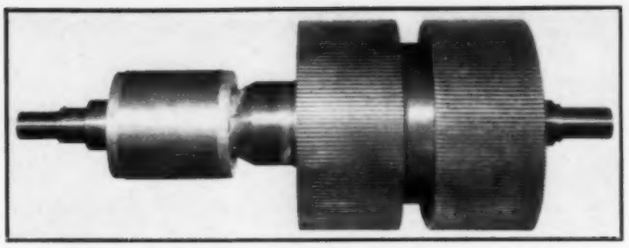


Figure 13 — Shown here is the shaft of the frequency-changer set illustrated in Figure 12.

for resistivity should be chosen to represent the average temperature. Assuming this to be approximately 800 F ($\rho = 45 \times 10^{-6}$), and with $\mu = 100$; Figure 10 shows the approximate depth of penetration as it varies with frequency.

Also plotted is what might be considered minimum strip thickness where $t = 2\,\delta$; on the basis that there will be no flux cancellation, which would occur if the depth of penetration exceeds half the strip thickness.

It should be noted that the induced current is distributed inward from the surface according to a diminishing curve and that for mathematical purposes δ represents the point at which the intensity of the induced current had dropped to $\frac{1}{e}$, or approximately 36 per cent of its value at the surface. This accounts for approximately 87 per cent of the heating on an I^2R basis ($1^2 - 0.36^2$). Another important factor to consider is what happens at the critical temperature at which the steel strip becomes non-magnetic. ρ may be ten times its value at room temperature; also $\mu = 1$ so that δ may increase more than 30 times. Much of the induced current cancels out and a point is soon reached where the rapidly increasing radiation loss equals the power input. This is illustrated graphically in Figure 11. Effective heating no longer results; unless the frequency employed is high enough so that δ is still small in the non-magnetic state. In that case, heat developed below the Curie temperature is in an extremely shallow layer, and is carried to most of the volume by conduction.

The optimum strip thickness for a given frequency may be determined mathematically, and is somewhat greater than $2\,\delta$ so that more of the induced current may be utilized without cancellation.

Conversely, for a given strip thickness, the optimum or base frequency as it is sometimes termed, may be calculated. Below this base frequency, rate of heating and efficiency are reduced; above it, they remain practically constant, so that no harmful effects result from using a frequency above base value.

EQUIPMENT

There are two basic types of induction heating equipment. These are power oscillators (also termed radio-frequency generators or electronic heaters), and rotating machines. It is impractical to build electrical equipment for each and every frequency that may be considered necessary for a given application, and, as previously shown, this is not necessary; 960, 300 and 9600 cycles have become fairly well standardized for rotating ma-

chines, 9600 cycles being the highest available in appreciable power sizes. For higher frequencies, electronic means are used. It is evident that this type is required for heating extremely thin strip; or for heating, much above the Curie temperature, most of the gages normally encountered. With electronic equipment, a frequency can be used which is high enough to effectively heat very thin materials; and also effectively heat at unit permeability.

Electronic equipment is characterized by:

1. High initial cost.
2. Relatively poor overall efficiency.
3. Relatively high maintenance and costly vacuum tube renewal.

These become very important factors in the high power levels we are concerned with in heating continuous strip. Rotating equipment is more attractive on all counts. For a given amount of power, its first cost is considerably less. Overall efficiency improves because the efficiency of frequency conversion with a rotating machine is substantially higher than with an RF generator. Maintenance should be materially reduced because conventional equipment is used, which requires a minimum of service and attention. As might be expected, strip thicknesses varying considerably from theoretical values can be efficiently heated with rotating machine frequencies, either by utilizing a portion of the current near the surface on thin materials or accepting some heat conduction on heavier gages. Examples are cited later to indicate some of the possibilities.

Electrical equipment consists essentially of a frequency changer set; control for its motor and generator; inductor coil; and capacitors.

Frequency Changer Sets—Figure 12 illustrates a 2-unit 2-bearing frequency-changer set as built in capacities through 250 kw. Figure 13 shows the shaft of such a machine, with the rotor of the 3600 rpm induction driving motor on the left and the rotor of the inductor alternator on the right. These machines are totally-enclosed and water-cooled; making them quiet in operation and free of troubles from dirt and foreign materials that can be drawn into an open machine. Journal bearings are used, with oil rings, and flood lubrication added on the larger sizes. No elaborate foundations are required—allowing them to be readily moved is necessary and permitting their location directly at the load if desired. A number of such machines gives a flexible power supply; if it becomes necessary to remove one of them from service, operations can continue at a reduced rate which would not be the case with one large machine. They may be readily paralleled if the need arises. Figure 14 is a view of a 2-unit, 4-bearing totally-enclosed hydrogen-cooled frequency-changer set, rated 700 kw, 9600 cycles. In approximately the same overall dimensions and for roughly the same cost, 1250 kw at 3000 cycles may be obtained. Such machines are more practical when the power requirements would necessitate an unreasonable number of small sets.

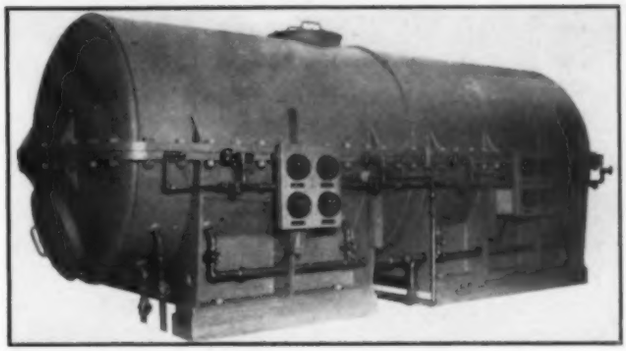


Figure 14 — This 2-unit, 4-bearing frequency-changer set which is rated at 700 kw, 9600 cycles, is totally enclosed and hydrogen cooled.

Control Equipment—Conventional motor starters or switchgear are used. A typical generator control panel is shown in Figure 15 (from left to right—front, side and rear views, respectively). While an open panel is shown for clarity, the cubicle type is recommended

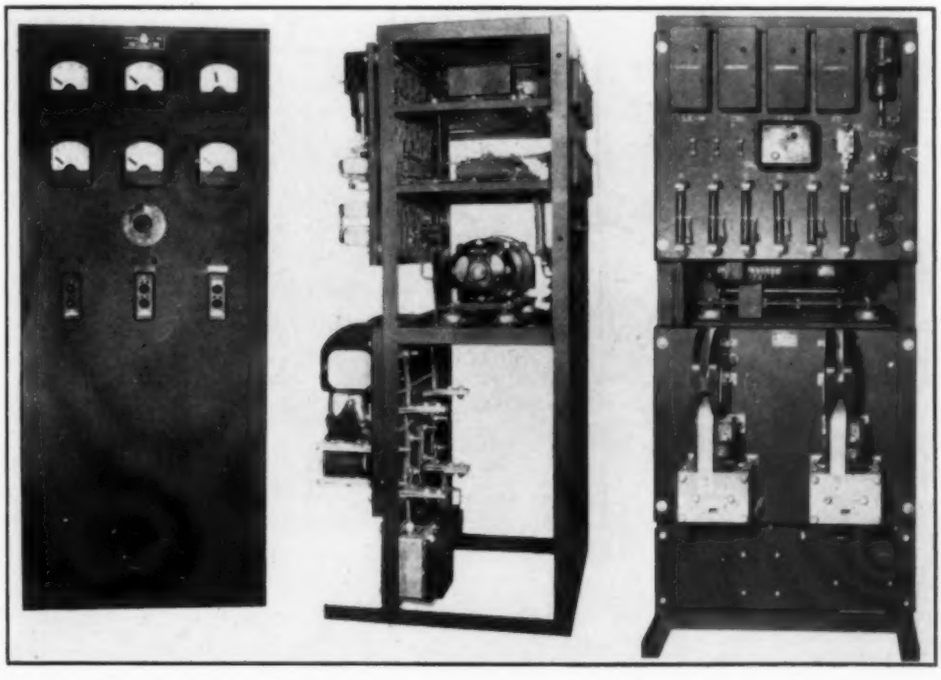


Figure 15 — Shown here, left to right, are the front, side, and rear views of a typical generator control panel. Conventional switchgear or motor starters are used.

for steel mill applications. Such a panel consists essentially of meters and metering transformers, high-frequency line contactors with instantaneous overload protection, and a motor-amplidyne set with sufficient control devices to operate it as a regulated exciter for the high-frequency generator. Power into the strip is thus controlled by varying generator voltage; the speed of response and field forcing ability of the rotating regulator providing an excellent regulator to hold a given setting. Various control devices may be used in the field circuit of the rotating regulator to vary power into the strip as a function of line speed so that, for example, too much power is not left on when operating at reduced speeds.

Inductor coil—The inductor coil is constructed of copper tubing and is water-cooled. Size of tubing is a design compromise between current to be carried, cooling water to be carried, and other factors. Coil voltage is low (usually 440 or 800) and insulation problems are easy compared to what is required for the high coil voltage encountered with electronic equipment. After a suitable number of turns to accommodate the generator voltage is determined, the necessary number of such multi-turn coils are then connected in parallel electrically and hydraulically by means of a header. The inside walls of the coil are protected with asbestos sheeting or similar material. A coil to transfer a given amount of power at 9600 cycles will be longer than that required for radio frequencies. However, its loss is not so great as to prevent good efficiencies, and the lengths required do not appear to impose any undue mechanical limitations.

The effective value of μ in the formula for depth of penetration can be varied over an appreciable range by proper coil design. A coil having a weak magnetizing force will effectively increase the permeability and thus reduce the depth of penetration. Conversely, a coil having a strong magnetizing force will increase the depth of penetration. This can be used to advantage for the particular thickness of strip to be heated. Test results have shown that it is possible to calculate the performance of coils very accurately.

Capacitors—The high-frequency generators are designed for unity power-factor so that their size may be kept to a minimum. Since the power-factor of the inductor coil will always be substantially lagging, power-factor correction is necessary. The method used is identical with the familiar practice on 60 cycle systems, where the capacitors are connected across the bus and their leading current cancels the lagging current of the coil so that all of the generator current goes into useful work. This differs from an electronic heater where high-voltage tank capacitors form the heart of an oscillating circuit. Figure 16 shows capacitor units of the type that have been used successfully on induction heating applications for many years. The internal assembly consists of several flattened rolls of high grade kraft paper between aluminum foil, hermetically sealed in a pyranol-filled metal case and arranged for water-cooling. One unit approximately 15½ in. high × 13½ in. wide × 5 in. deep provides 300 kva at 9600 cycles. Taps permit ample adjustment. It is important to locate the capacitors as near the inductor coil as possible, to keep to a minimum the losses in the bus carrying heavy current between the coil and the capacitors.

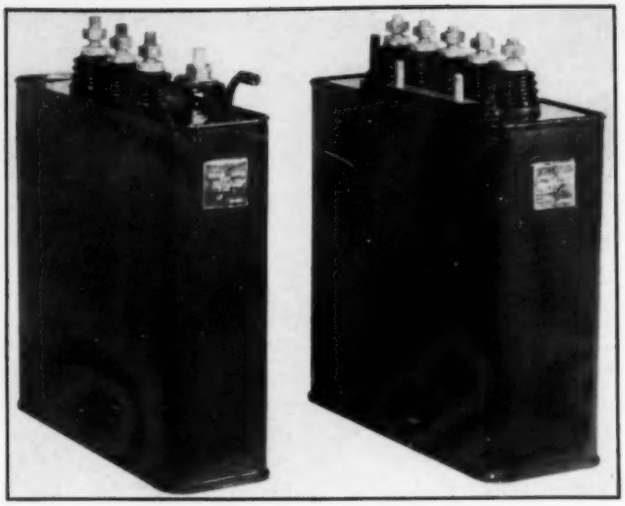


Figure 16 — Capacitor units of the type shown here have been used for many years in induction heating applications.

The losses in this method of heating are composed of:

1. Loss in frequency-changer set. Efficiencies of machines illustrated will vary from approximately 78 per cent for a 150 kw set to 85 per cent for the hydrogen-cooled machine (at full load).
2. Losses in cable or bus from generator to coil and from coil to capacitors. These may be kept to a minimum by avoiding long runs, use of concentric cable, etc.
3. I^2R loss in inductor coil.
4. Loss in capacitors. This is low; 4 watts per kvar or less.
5. Radiation and convection loss from the strip.

APPLICATIONS

Low temperature—Flow brightening of electrolytic tin plate is a promising application for 9600 cycles. The fact that the tonnage produced by the electrolytic method now exceeds that by the hot-dip method, and that many producers are giving consideration to increased reflow capacity has prompted an investigation of the feasibility of using rotating equipment. We are dealing with thin material, which indicates a higher frequency, but, fortunately, also with low temperature (under 500 F).

ρ is low and μ can be made high by coil design, both of which decrease the depth of penetration. Even then, a frequency in the order of 28,000 cycles is indicated for 10 mil strip (see Figure 10). The question to be answered was whether the useful induced current with δ almost equal to strip thickness will heat to the required temperature and with an acceptable efficiency.

Preliminary tests gave promising indication that the desired results were attainable. Later, thorough tests made with full-scale strip handling facilities, including quench, produced satisfactory tin plate and gave, as one example, the following result:

Strip size ..... 27 5/16 in. x 0.0093 in.
Speed, fpm 100

Volts (at coil) 422
Kw (at coil) 81.5
Calculated heat absorption, kw
(from 86 to 450 F*) 66.3
9600 cycle efficiency ..... 81.5 per cent

*Actual temperature will somewhat exceed 450 F; calculated efficiency is therefore conservative.

The coil used in these tests is illustrated in Figure 17. Three of the Type HF capacitor units provide ample corrective kva. Conclusions from these tests are:

1. 9600 cycles can be successfully used to reflow tin.
2. An overall efficiency (that is, 60 cycles supply to actual Btu's in the strip—or, 9600 cycle efficiency X frequency-changer set efficiency) of a minimum of 60 per cent can be obtained on 0.0093 in. strip. this would approach 70 per cent if a large hydrogen-cooled machine were used. Below 9 mil thickness, as might be expected, the 9600 cycle efficiency falls off, so that at 8 mils the overall would probably be between 45 and 50 per cent.
3. The coil length for 30 in. wide strip may be estimated by using 30 kw per foot.
4. Attractive economies from the standpoint of heat cost and maintenance cost should be possible with this method.

A typical line would be one to handle 30 in. × 0.010 in. strip at 600 fpm. Required installed capacity is about 1 kw per fpm, so that four 150 kw sets with four separate coils would make a desirable arrangement. A photo-electric scanner, operating on the difference in reflectivity of mat and reflowed finish, would be used through rotating regulator control to hold the flow line by varying the power input to the inductor coils.

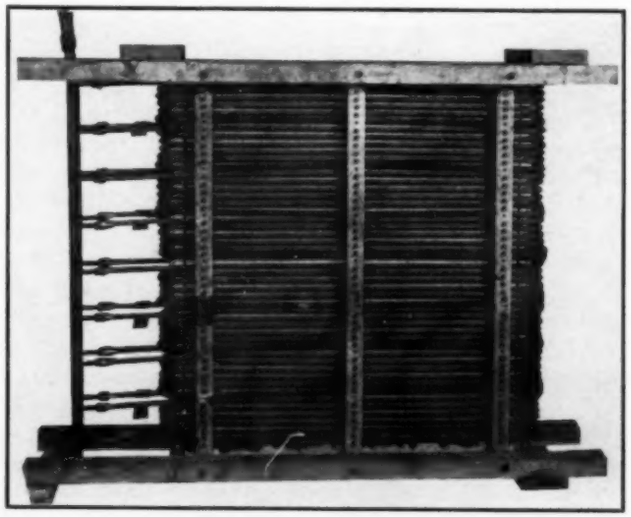
Heavier gages and higher temperatures—Figure 18 shows a proposed design for an induction unit for the heating of steel strip, 48 in. nominal and about 54 in. maximum width. It is intended for operation with a protective atmosphere and is equipped with suitable gas seals. Adjustable guide rolls accommodate various strip thicknesses. It is designed to use as a power source, two standard 700 kw, 800 volt, 9600 cycle single-phase totally-enclosed hydrogen-cooled frequency-changer sets; operating in parallel and connected to two copper tubes for a power bus.

A number of multi-turn inductor coils are provided; brought out through the furnace wall with stuffing-boxes. Two coils are connected in series hydraulically and obtain their cooling water, through rubber hose, from header pipes. Each pair of coils is equipped with a protective water flow switch. Power is brought to each coil by water-cooled copper tubing, clamped to the coil ends and fitted with two unions to permit ready removal of coil if necessary. This copper tubing extends above the coils so as to connect a capacitor across each coil, as well as to provide cooling water for the capacitor. The capacitors are mounted as close as possible to the coils to minimize the loss in the bus between coil and capacitor, which carries the heavy corrective current. Taps on each capacitor permit an adjustment for each coil; in addition, trimming capacitors, contactor operated, are connected directly across the power bus for the final adjustment for unity power-factor on the generators. As many of the inductor coils as desired (dictated by the widths and gages to be handled) may be made readily switchable from the power bus by means of contactors. The coil design would be based on the size of strip representing the bulk of the production. If this design is for thin strip, and substantially heavier gages are to be heated, some of these coils may have to be cut out for best operation, since the flux will be utilized more effectively. If the coil is designed for average strip thickness, little coil switching should be necessary except for wider strip, where fewer coils would be used to prevent overloading; and for narrower widths, where coils should be added to utilize full power and maintain the same tonnage. This unit could be about half the length shown if no provision was made for adding coils on narrower widths.

It is estimated that such an equipment would be capable of heating approximately 10 tons per hour to 1350 F. Temperatures of at least 1500 F could be obtained at reduced speed. Available test data indicates an over-all efficiency (60 cycle motor input to actual Btu's in the strip) of at least 75 per cent for a strip thickness in the order of 80 mils; this decreasing sum as the strip thickness decreases. This efficiency is some less than for a properly designed electric furnace for the same output; however, it is estimated that an electric furnace at least 75 feet in length would be required for equivalent heating.

It is interesting to note that in this proposed unit the power density is about 50 kw per square foot of strip; whereas in the flow-brightening application it is only about one-fourth of that.

Figure 17 — Shown in this photograph is the coil which was used in making preliminary tests on the use of induction heating for reflowing of tin. These tests indicate that attractive economies should be possible.



SUMMARY

Induction heating of steel strip should be useful for a variety of continuous processes. Many of these applications can utilize rotating-machine frequencies, which is desirable whenever possible from an economic standpoint.

It is seen that thickness of strip and desired temperature are important considerations. Nine or 10-mil material can be efficiently heated to moderate temperatures using 9600 cycles. The heavier gages can be efficiently heated to their Curie temperatures using rotating-ma-

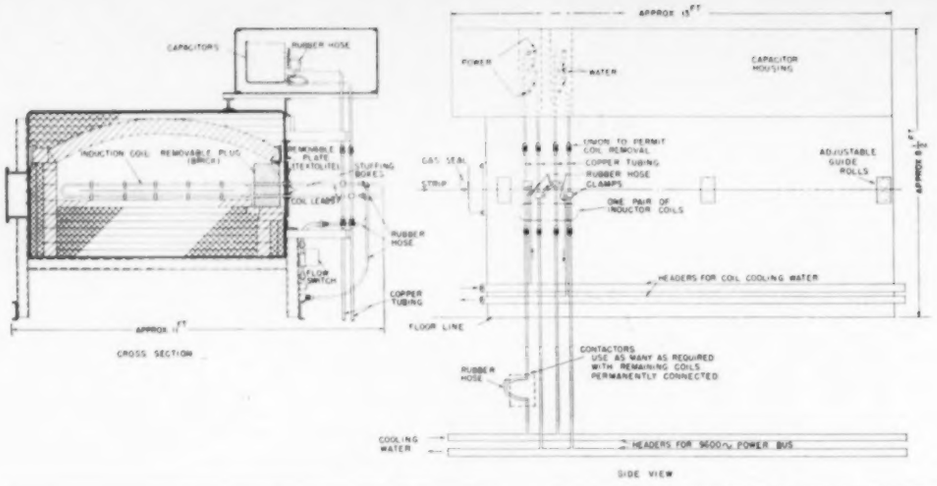


Figure 18 — This sketch shows a proposed unit for induction heating steel strip for continuous processing.

chine frequencies and somewhat higher temperatures can be attained, but at some sacrifice in efficiency; 3000 cycles and possibly 960 cycles should be considered for the heaviest gages, as it is more economical.

An induction heating unit such as illustrated in Figure 18 might be used for such applications as providing a rough or semi-anneal. Where controlled cooling is required, such a unit could be used in combination with a cooling chamber, and this chamber may be provided with both heating and cooling features if desired. Where higher temperatures are required, such as for full annealing and normalizing, this induction heating unit could be used in combination with an electric furnace to attain the higher temperatures and provide equalizing or holding. The triple combination of induction preheat, furnace and cooling chamber could also be used.

Possibly, induction heat could be used to advantage in the pickling of hot-rolled strip. An induction preheat to the strip as it enters the pickling line would make it unnecessary for the steam to heat the strip, thus perhaps making it possible to shorten the length of the first tank or enabling more production from a given length of tank. If steam is admitted directly to the bath, less dilution of acid would result; which should mean more effective cleaning as well as a saving of acid. Undoubtedly there would be mechanical problems to be overcome. Certainly induction heat could not be justified over steam on the basis of heat cost alone, but a study might show the resultant advantages to be worth the investment.

The information presented herein may suggest other applications.

DISCUSSION

PRESENTED BY

R. M. BAKER, Advisory Engineer, Westinghouse Electric Corporation, Baltimore, Maryland

ELI SHAY, Electrical Engineer, Wean Engineering Company, Warren, Ohio

F. E. ACKLEY, Induction and Dielectric Section, General Electric Company, Schenectady, New York

F. O. SCHNURE, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Maryland

JOSEPH VERNON, Electrical Supervisor, Weirton Steel Company, Weirton, West Virginia

ROLAND BANGERT, Assistant Electrical Engineer, Weirton Steel Company, Weirton, West Virginia

M. D. STONE, Manager, Development, United Engineering and Foundry Company, Pittsburgh, Pennsylvania

A. J. MORGAN, Sales Engineer, Aetna Standard Engineering Company, Youngstown, Ohio

R. M. Baker: The story the authors have delivered gives a good accounting of the methods and equipment being used successfully in the steel industry for the continuous heating of steel strip. My company has been interested in all of these applications and has done a good amount of experimental and development work along these lines both in our research laboratories and in our industrial heating divisions. We are convinced that continuous heating is something which the steel industry requires to fit in with their present high speed production methods. Each of the methods described by the authors has certain fields of application, and in the case of certain processes, two or more of these methods offering possibilities should be carefully analyzed from both an economic and engineering standpoint before one can be chosen for the particular process. In some cases, combinations of two or even more of the methods may offer the best solution to the problem.

We would like to discuss particularly the use of induction heating for the brightening or flowing of electrolytically produced tin plate. We have installed about 9000 kw of 200 kc radio frequency heating equipment on tin reflowing lines, and have also produced much of the electrical equipment that has been used in conduction heating lines.

As pointed out by the authors, it is possible at 9600 cycles to supply about 30 kw per foot of coil length to a strip 30 in. wide by 0.010 in. thick at a reasonable efficiency. For a strip speed of 1000 fpm this represents an active coil length of approximately 33 ft. If still higher speeds, of the order of 1500 fpm are used, the active coil

length required would be approximately 50 ft. Thinner strip requires, for comparable efficiency and speed, an even longer coil.

The above considerations force one to accept one of two alternatives: a very long unsupported length of strip, or sectionalization of coil and the addition of supporting or guide rolls over which the strip must pass at elevated temperatures.

If radio frequencies are employed it is possible to supply a power density of about 350-400 kw per ft length of coil or more than 10 times the maximum feasible power density obtainable at 9600 cycles. This simply means that instead of requiring an active coil length of 35-50 ft, an active coil length of 3.5-5.0 ft can be used.

With mills presently producing tin plate material reaching speeds of a mile a minute, and with plating line speeds being increased, it may be that the future will see reflowing equipment required to operate at speeds well in excess of 1500 fpm. Using radio frequency, tin plate is now being reflowed at speeds of 1200 fpm, and the handling problem at increased speeds is not too difficult because of the short coil length which can be used. The successful use of 9600 cycles for high speed operations will depend not on the ability to heat the strip at this frequency, but rather on the solving of the more difficult strip handling problems brought about by the necessarily long coil lengths required.

Eli Shay: Mr. Ryan and Mr. Ackley have made an important contribution to the literature of continuous strip steel processing by presenting in one paper the strip heating problems and their solutions, using one or more of the basic methods; namely, furnace heating, resistance heating, and induction heating.

Of particular interest to us is the comparison of resistance heating methods with induction heating at 9600 cycles, as applied to flow-brightening of electrolytically deposited tin or tin plate. It will be interesting to compare the two methods of doing the same job with respect to cost of equipments, operating costs, and the ultimate results. After studying such data, advantages and disadvantages may be determined and equipment selected that offers the greatest number of advantages.

The objections raised to resistance heating with a single phase load may be overcome by making the load 3 phase delta. Should a transformer go out, the system may be operated in open delta. This scheme would eliminate the ground current limiting reactors, as well as give balanced conditions of load. In any case, the method selected for heating strip that is moving at a given velocity will be selected after careful consideration of the desired results.

F. E. Ackley: We appreciate the comments of Mr. Baker. There is no one else, to my knowledge, better qualified to discuss the relative merits of one frequency versus another, and what it involves in the use of the inductor coils. I have read, and perhaps you all have read, his previous publications on this subject; and he is certainly to be complimented highly on the original work which he did in the design of coils.

We have studied these and we have been able to check with our own experiments the formulae which he gives. What he says is certainly true, that it will take a longer coil to use rotating frequencies for these thin strips, and we agree that it will be three or four times as long. But the point we raise is, "Are not all of the benefits derived by using rotating machine frequencies worth it in lower cost equipment and lower cost of operations, provided it will work mechanically?" So far we have seen no serious objection to the use of these longer coil lengths. We have not done it on a full scale, but we think we can.

Some resistance heating installations now in successful operation for reflowing, heat approximately a 40 ft length of the strip. This is divided in unsupported lengths of about 20 ft on both the up and down pass in the reflow tower, and the partially heated strip is not marked by passing over a roll at the top.

A power density of 400 kw per ft of active coil length may be possible with radio frequencies. Existing installations with which we are familiar employ approximately 200 kw per ft of active coil; when the high-voltage insulators and supporting structure are included this is nearly 2 feet, so that the total length of coil through which the strip passes is, for 1200 fpm, about one-fourth of that required for 9600 cycles.

Mr. Shay mentioned the matter of coil voltages. I did not mean to say that 440 or 800 volts were low for general steel mill use. Of course they are not, but the point I tried to make was that 440 or 800 volts on an inductor coil is really low compared to the high voltages which are encountered on electronic methods of heating. These run into several thousand volts and have required a great deal of work and effort to eliminate corona trouble and insulate for the high voltage which is inherent in an oscillator design. My point was that for that coil voltage, 800 volts and below is easier to handle, requires less space for insulation, etc.

I did not understand Mr. Shay's question on coil spacing. If he means the distance from the inner wall of the coil to the strip, that would be something in the order of 2 inches, or perhaps a little less, and the inside walls of the coil would be lined with asbestos sheathing or similar material.

F. O. Schnure: This paper covering the fundamentals of the three basic methods of electrically heating continuously moving steel strip is a valuable contribution to the art, inasmuch as it presents data involved in designing and operating each type of equipment as well as pointing out their advantages and disadvantages.

Not having had practical experience with furnace or resistance heating and only experimental contact with the induction method, I cannot comment authoritatively on either. However, it would appear that induction heating utilizing rotating machine frequencies, as applied to the reflowing of tin where the product is passed through a loop and not subjected to the hazards of furnace exposure or marking from current carrying contact rolls would be superior.

The high speed frequency changer should not present the maintenance problems incident to contact rolls and their brush problems.

Joseph Vernon: I have seen both methods of reflowing tin on electrolytic coated plate in operation; heating the plate by the resistance method, using the strip as a conductor in the circuit, and by using the electronic high frequency induction method. I am not so well qualified to speak on the former method as the latter. Careful consideration should be given to the application of electronic control. It depends on how quickly a

job is to be done, the production desired and the cost of equipment as to the type of heating to be used.

Most any application of electronic control is going to be expensive because the quicker a job is to be done the more it will cost to do it. If the time is cut in half, it may cost twice as much to do the job. High production of tin plate requires a high speed line and a steady operating schedule. At the present time high frequency induction heating is the answer to reflowing tin on strip speeds of 600 feet per minute and up.

In our experience with electronic induction heating, the maintenance has been considerable, but with cooperation from the manufacturer of the equipment we have made improvements during the past four years, which we believe will eventually pay for the cost of developing this type of equipment.

We, at Weirton, West Virginia, entered the field of electrolytic tin plate production by operating our lines at approximately 700 feet per minute. In time we were able to attain a speed of 1000 feet per minute. At the present time we are plating a strip 30 in. wide by 90 lb base weight at 1350 feet per minute.

Heating the strip at the above speeds is accomplished by passing the strip down through five induction heater coils which gives a heating zone of 12 feet. The power for the heater coils is obtained from six 200 kilowatt high frequency power oscillators, operating at an average frequency of 160 kilocycles at approximately 12,000 volts.

I believe that it will be possible to use a combination of high frequency power oscillators and the 9.6 kilocycle, 440 volt power from the rotating machine, covered in Mr. Ackley's paper, to obtain a speed of 1500 to 2000 feet per minute, the low frequency power to be used as a pre-heater for the strip before entering the induction heater coils.

Each method of heating has its own benefits, its advantages over some other method. After four years of experience with electronic heating, we believe that it is the best method to use to obtain a high production of tin plate.

Roland Bangert: It seems to me that there are different applications for the different types of heating depending upon the job that you are attempting to do with it. I would like, however, to ask this question. Is it the economic factor of initial and operating costs that determines the frequency and the type of equipment used, or is it the work to be done that is the determining factor? It appears to me that some jobs can best be done at frequencies above those available from rotating machines although the initial and the operating costs may be higher.

F. E. Ackley: I think I would answer that by saying that the job you are trying to do is the first consideration. I would analyze that job for its frequency requirements, then I would see if I could use the more economical method employing rotating machines. I have tried to give some bench marks of where that method might be used. If I thought I could, then I certainly would use it. I think the most important thing is the work to be done, and then do it most economically.

M. D. Stone: The authors pointed out particularly the important roll of convection heating in resistance furnaces on bright strip. I would like to comment that if high velocity air is used (and it can be, economically), the amount of convection heating can be increased three to fourfold. We have run some experiments in which we have demonstrated this, and that it can be as good a way of heating as radiation heating itself. Possibly a combination of the two is what you will actually end up with, however.

The choice of one or the other of two or three types of heating, depends, as everyone recognizes, on the type of problem you have to solve. We run into quite a number of types of problems, and where conduction heating may be applied, it promises a very satisfactory solution to the problem. Its potential efficiencies are very high. The amount of equipment involved is low in cost, and relatively simple mechanically, and where holding times are not involved, which, as has been mentioned, cannot be worked into a conduction heating system, I would say it has a pretty good future. There are heating problems both in the ferrous and nonferrous fields that will permit this, and its use in the reflowing of tin at low temperatures has been one outstanding example in the ferrous field.

In high frequency induction heating, the reaction that one gets when one considers it, is first, its relatively high cost of initial installation, as well as its relatively low operating efficiency and therefore relatively high cost of operation. Therefore, I was particularly glad to hear of the efforts that have been made to work out systems using lower frequencies. I feel that there is a good possibility along those lines, as has been demonstrated in other fields a number of times. I remember that during the war a good deal of heating of shell noses was carried out with 1000 to 3000 cycle power. The wall thickness of the shells was pretty heavy and relatively low frequencies could be used, but one courageous manufacturer worked out a system of heating bomb noses which involved even thinner walls, by using 60 cycles, and did equally as good a job, with equally as fast heating, by resorting in that case to magnetic cores being placed inside the tube while the coils were on the outside. So, there apparently are possibilities, and very reasonable ones, for reducing the frequencies that are required in induction heating and the attendant first cost of equipment as well.

Along these lines, there probably should be mentioned another possibility of induction heating—I think many people are familiar with it and it is somewhat similar to the bomb heating problem as it was worked out—in which the flux is traveled transversely of the strip rather than longitudinally, and there that application is permissible, apparently again, low frequencies of the order of 60 cycles will permit a relatively satisfactory solution to the problem.

A. J. Morgan: As builders of machinery for the steel industry, we are at the present time engaged in the installation of three controlled atmosphere type furnaces, one of which is an induction heating unit. We expect to have considerable data on the operation of this unit very shortly. We have many times gone to Mr. Ackley's company for counsel on furnace recommendations and have found their extensive experience in this field to be very valuble. There have been times when fuel costs have had a great deal of influence on the selection of equipment, due to the geographic location of the installation.

THE PURCHASING AGENT'S CHANGING STATUS

By HARLAN E. CROSS, General Purchasing Agent
Sloss-Sheffield Steel and Iron Company
Birmingham, Alabama

HARLAN E. CROSS

. . . . even if management is not willing to approve a first rate purchasing department, it will still pay for one through higher prices, poor planning, and unreliable sources . . . .

▲ NOT long ago an editorial in one of our trade papers depicted the changes a modern Rip Van Winkle would find if he had started his long sleep in 1927 and wakened today. What changes he would find! "Yawning and rubbing his eyes," the writer stated, "this 1927 Rip would notice first of all a change in the ladies—more slacks, more cigarettes, toeless shoes, etc. Automobiles would be more streamlined, planes would zoom by overhead, larger and at a faster clip.

"Rip would be mildly shocked at the prices—the cost of living index would have risen from 124 to 156. Food would be up from 132 to 188. Wages in manufacturing industries would have risen from $28.00 to $49.00 per week. He would be shocked to find that his per capita share in the public debt had rocketed from $156.00 to $1830.00.

"He would find that radio had become big business. In between laughing at the gags of millionaire comedians as Messrs. Benny, Crosby and Hope, he would receive much fervent advice on which cigarette to smoke, which soap and toothpaste to use.

"Rip would find that the president he knew in 1927, Calvin Coolidge, was long since dead, but Vice President Dawes was still active as a banker. He would never have heard of Franklin Delano Roosevelt, Chamberlain, Hitler, Tojo or Molotov. Such products as nylon, FM radios, penicillin and electric shavers would be dramatically new to him."

But the person whom he would miss in the greatest number, and without any regrets, would be the 1927 model purchasing agent of 20 to 25 years ago. In order to see the changes Rip would have found, let us look into the past and refresh our memory on how the purchasing agents job was started and what kind of a fellow he was like in that period.

George Aljian, past president N.A.P.A., sums it up as follows: In the good old days, if the main office needed some pens, or paper or typewriters somebody from that department just went and bought them. If the mops or brooms wore out, the janitor stepped down the street to the hardware store and obtained new ones. If the erecting shop wanted bolts or steel, one of the foremen or the superintendent went out and brought them back, and so on down the line.

As business became larger someone had the idea of funneling the requirements of all departments through a single channel, not only for advantages which could be gained through combining the wants of several departments and obtaining quantity prices, but also to facilitate recording and paying for goods received. Thus the buying was placed in the hands of one centralized buyer or buying staff. And what was this purchasing agent like? Let us look over his shoulder and watch him work.

Every Monday, or maybe Tuesday, or maybe it was every day, this 1927 model P.A. received a flock of requisitions from his plants. He spent an hour or so sorting those requisitions meticulously. All the nuts and bolts were placed in one pile; all the files, the bar stock, and pipe and fittings found their pile. Then these requisitions received a second sorting to see that the fifty $\frac{3}{8} \times 2\frac{1}{2}$ bolts that the carriage shop wanted were paired up with the 175 of the same size the boiler shop needed, and so on down the line.

Then the P.A. went to work sending an inquiry on each batch to at least three bidders and the man who bid the lowest received the business. And that was the beginning and end of that week's requisitions, unless, of course, the vendor supplied some faulty merchandise,

Presented before the AISE Birmingham District Section Meeting, November 24, 1947

in which case our hard working P.A. turned the whole thing over to some other department and let them do the worrying.

He did a good mechanical job; in fact batted 1,000, but mentally he was a bush leaguer. You may think this is an extreme picture? However, a widely accepted text book on salesmanship in our colleges for a number of years past was written in 1927 by Charles H. Fernald, M.B.A., who summed the purchasing agent up as follows: "His function is defined as purely clerical, his objective solely concerned with the lowest possible price; his method confined to getting bids; his equipment—a cabinet full of catalogs and numbers of potential suppliers; his technique—to play one company against the other for price advantage; his authority—absolutely nil." His advise to salesmen "get around him whenever you can."

But for some of the things that happened while our modern Rip was napping—that might still be the description of many of the purchasing agents of today.

However, early in the morn of Rip's sound slumber the clouds of war gathered ominously over the countries of the eastern hemisphere; and with its characteristic suddenness the lightning of Mars flashed sharply here and yonder, setting aflame with the fires of battle, many nations totally unprepared to cope with such a fierce conflagration.

At first, watching from a distance, we soon found the sparks spreading to this country's shores and possessions, making it necessary overnight for this nation to put its entire united efforts toward attempting to quell the holocaust. It was necessary for factories and industry to quickly move into high gear production, and necessary for thousands and thousands of tons of raw material to be provided and fed into factory machinery so that million upon millions of items of finished machine tools, armament and war equipment, food and clothing could be manufactured, packed and shipped to keep our war machine moving at top speed.

The purchasing man became overnight a very necessary person with a most important job to do. There was no time now for trifles, no time for unimportant details or routines. Action, quick thinking and sound judgment were the orders of the day. For the production man became too busy with producing, and the engineer too busy with designing and research to have his time taken up with hunting and buying material. Often before a firm could agree to produce an order for so many million shells or thousands of tanks or planes, it had to call in the purchasing agent with engineering, production, and management to see if the necessary materials could be secured, and how quickly.

Sometimes the purchasing agent had to say that certain materials were unavailable and be ready to suggest and find suitable substitutes with which to do the work. Often the P.A. left his desk and went to the factories and "sold" his firm's need for materials, and then would see that they were expedited to his plant in time.

With so much depending on the knowledge of what, how much and when, very few companies were so impractical as to consider production schedules without the man so vital in procuring materials being in the conference.

With such stress on purchasing ability and quality of purchasing personnel, it is no wonder that most of the shallow thinking, detail handling 1927 model purchasing agents were swept away by the storm. It was fortunate for both industry and the purchasing profession, that a new type of purchasing agent was forged into being through the heat of trial, fortunate for both the purchasing men and industry of today that management, which has always included production and engineering, found a new ally and a new member of its executive council. However, in so including purchasing as a part of management, management established certain requirements which it expects from its newly treated executive. These standards by management form the basis of the changing position which Rip, on waking in 1947, or any operating or sales engineer, or even the purchasing agent himself finds today. For like the man, on the train looking into the mirror to shave sees the face of the same person who boarded the train the night before, he realizes he is miles away from the place he formerly stood.

Is this view shared by management? Let us see. Mr. R. H. Hargrove, vice president and general manager United Gas Pipe Line Company, Shreveport, Louisiana, and president, American Gas Association, wrote recently on "Purchasing from the Management Viewpoint"; "In the past twenty-five years the field known as purchasing has evolved from a rather hit-or-miss proposition to a highly specialized science. Its importance has so grown in the minds of management that in World War II the purchasing agent ascended to an executive plane. Now that the war is over, management has conceded that the procurement problems to be met in peacetime are of equal importance, though of a different character, with those faced during the war. Management has wisely acknowledged that any department which supervises the outlay of an amount of money which represents a goodly portion of the total expenditure of the organization must of necessity assume its proper important role in the workings of that organization."

"Primarily," he continues, "we must recognize the self-evident fact that the handling of procurement by a highly trained man or men, takes a tremendous responsibility from the hands of executives and operating men, and permits them to devote their time to other duties. Conversely, it removes the very dangerous authority of responsibility from the unskilled employee, who may know his or her particular work well, but who knows little or nothing of the fine points of purchasing, thus saving needless waste of money on the part of people who can buy but cannot purchase."

If purchasing is advancing to a new plane, let us examine this modern and changing status to see what benefits and changes of relations it brings to operating and management men.

First the scope itself of purchasing is being changed, since the definition of the purchasing function is no longer restricted to the function of a buyer or an order placer. To be sure, there must be buyers on every purchasing department staff, and most purchasing agents, among their other activities, act in the capacity of buyer. But when the job is coldly and permanently defined, that definition should be sufficiently broad and inclusive to embrace the full scope of a complete and

progressive purchasing program. Specifically it should take into consideration the buyer's interest in the many incidental functions that affect the materials program and influence purchasing performance such as specifications, inventory policy and control, quality control, production planning and others which may or may not come within the purchasing responsibility, but nevertheless have a large part in determining the effectiveness and the opportunities of purchasing.

This does not imply that purchasing should claim the whole company operation as its field, or that it should step on the prerogatives of other departments that also have an interest in these various activities. However, in defining the scope of all departments, purchasing included, it is essential to recognize that all of these phases of the company's material problem are matters for cooperative decision, and that no decision is properly made in the company's interest until the purchasing viewpoint has been given full consideration and weight.

However, purchasing is discovering that the broader the definition of the scope of purchasing is, the broader must be the level of purchasing performance and proficiency. If our job as buyers is to get maximum value for the company's dollar, it is equally our responsibility to see that our company gets maximum value in competent purchasing. For it costs money to maintain and operate a purchasing department. However, just as sales cost is a recognized factor in business, so procurement expense is equally a legitimate cost of business operation and not merely a necessary evil.

Further, if there is any merit in the principle of centralized purchasing, and management says there is, a company must realize that it is paying for the very best possible purchasing department, whether it has such a department or not. A management may not be willing to make the expenditure for a first rate department, nevertheless, it is paying for the best in the form of higher prices, inadequate planning, unreliable sources, excessive costs of transportation and expediting, inventory and production losses, and in the divided effort of those who ought to be giving their full time and attention to their primary duties of engineering, production or other phases of business instead of dabbling in dealings with salesmen and vendors of materials. Just as we look at the end cost of products in our buying, so we must look at the end cost of the purchasing operation in relation to what it contributes in proficiency to the company's benefit.

In order to secure this proficiency, mind you not just efficiency, management has set up the following personal qualifications that belong in its definition for proficient purchasing:

1. Management expects the director of purchases to maintain a functional approach to his job. This requires resourcefulness and insight by the purchasing officer. The purchasing responsibility does not begin with a requisition for specified materials but with the need for a certain result to be achieved.

A mid-western manufacturer of metal goods made plans early in 1946 to triple production. The raw materials and production capacity necessary were both available. But the product was one that required careful packaging, and to triple the purchases of corrugated paper in a scarce market presented a bottleneck that production officials had not foreseen and threatened the entire program. The purchasing agent, quick to see this, called it to the attention of his colleagues. He did succeed in obtaining 70 per cent more corrugated, a major achievement in itself, but this brought him slightly more than half way to his goal. However, this purchasing man attacked the problem as a packaging materials requirement rather than seeking corrugated paper alone. Other methods of packing were investigated and tested, many discarded as impractical, but in due course, a solution was found involving different packaging materials and methods, satisfactory as to cost and performance, and acceptable to design and sales executives, enabling the production goal to be reached in the last quarter of the year. This feat could not have been accomplished if purchasing had not been consulted in the earliest stages of planning, nor if purchasing research had been constricted by specifications in which the purchasing department had no voice. Purchasing on the basis of functional use or need is a primary factor for proficiency and is what management expects.

2. Management requires that the purchasing man must know materials, what they will do and how they are used in his plant. He, therefore, should know the facilities and operations and basic requirements of his company.

Recently at a round-table discussion, one buyer remarked he had just had a stroke of luck. He had been in the market for a large quantity of scarce soft steel strip. At 11 o'clock that morning, a nearby steel warehouse telephoned they had 90,000 pounds, not in the exact size wanted, but available if he could use it. From his intimate knowledge of his plant he knew the material could be used by edging to meet the need, so he placed the order forthwith.

Another buyer, at the table seemed crestfallen. "So that's what happened to the stuff." He too had been offered the strip, but by the time he referred it to a plant man, who could not be located until after lunch, the strip which his company could also have used had been sold to his better informed and more proficient colleague, who also had the authority to make such decisions.

3. The proficient purchasing man is expected to know the production methods and materials of his suppliers. The purchasing agents during the war, probably more than any other group in industry, became exceedingly familiar with the foundry practices and facilities of this country. Many of them report having stayed with a job on the foundry floor a number of hours at a stretch to get the "bugs" out of a particular casting. One of these men had a requirement that called for 2000 castings a week of one design. No foundry would guarantee him more than 10 per cent of that quantity. When he went out into the field to find why he learned a relatively simple change in pattern design would so simplify production and speed output that the bottle neck was quickly broken and a substantial cost savings was affected in the bargain.

4. Management expects its purchasing agent to know where to buy.

A purchasing agent was called to a new job in 1946. He did not know why the other purchasing agent had

been replaced but soon found out. For on his desk to greet him was an accumulation of requisitions, some of them three months old, on which no definite action had been taken because his predecessor simply did not know where to place the orders for these critical materials with any hope of reasonable delivery when his normal established sources failed. Proficiency is partly a matter of experience. Within a relatively short time this more ingenious buyer had the wheels of that plant turning again. Thorough purchasing should not be too rushed, but prompter procurement is possible when the purchasing man knows where to buy, and when that knowledge is supported by the essential tools of purchasing: good records, sound vendor relationships, and foresight and planning, cooperatively by both purchasing and production. I have never found an instance when production men, on being advised, by purchasing in advance of an impending scarce material situation, were not willing to purchase sufficiently in advance of requirements to avoid work delays.

5. The purchasing executive is expected by management to know costs. This means more than having access to price lists or requesting quotations, any one can do that; but he must know what goods ought to cost, the basic costs of materials and operations that go to make up a suppliers price. He must have this information to satisfy himself that the prices he pays are reasonable. He must have it to assist his own cost, engineering, production and sales departments in making estimates and to aid management executives in their policies and planning. Acquiring that information is an endless process calling for lively and intelligent inquisitiveness, implemented by constant research and analysis.

6. Management expects its purchasing man to command the respect and confidence of other departments and work with them.

Before deciding to make or buy an article, your purchasing agent's information is essential to your production men in arriving at a decision. Before drawing up specifications, your purchasing agent's knowledge of availability and price is necessary to your engineering force. What a wide field of discussion this topic of specifications would open.

Have you ever thought of your purchasing department as a training school for your salesmen, where he can listen to the sales talk and techniques of other salesmen. Also, before one buys an idea for sales promotion, check with your purchasing department and you may save your sales department a lot of money by finding several other firms are already using the idea and that it is not too good.

Of course, top management always has the final say in policies of make or buy, sales promotion, and reciprocity, but if the purchasing agent is to serve his company well, he is expected by management to have a sound conviction on all these policies that affect the materials program, and he must see to it that this purchasing viewpoint is given due consideration even though it does not prevail. For purchasing has a responsibility to management to get, and to give maximum value for the purchasing dollar.

Only a few weeks ago in a public conference, Arthur G. Pearson, director of purchases for the American Meat Institute, Chicago, said: "Management is insisting that the purchasing department carry its share of executive responsibility. Business leaders have no patience with the purchasing agent or purchasing department that does only the work that any errand boy might do."

That is the direction of purchasing development over the past two decades, which is steadily gaining momentum, and which indicates the changing status of the purchasing profession. Its indication is a warning and a light, a warning to the purchasing agent who attempts to tie himself to the outmoded routines and practices and does not ride with the rising tide of progressiveness and proficiency, a light to the operating engineering and sales professions which should permit them to see and assume that the purchasing man now is a more capable and authoritative buyer than the men with whom it was formerly their practice to deal.

DISCUSSION

PRESENTED BY

H. E. CROSS, General Purchasing Agent, Sloss-Sheffield Steel and Iron Company, Birmingham, Alabama.

Member: What is the attitude of the National Association of Purchasing Agents on price increase clauses?

H. E. Cross: Not answering officially for the N.A.P.A. but as an individual who has heard this same question put before N.A.P.A. conventions, the general attitude of the majority of purchasing agents is that price escalator clauses based on definite causes of price increases and which also permit downward escalation if the causes that effect prices make for a decrease, are fair and allowable. However, most purchasing agents object to a price increase clause which permits no ceiling on a seller's price. Some purchasing agents and manufacturers make agreements that limit escalation to a certain maximum percentage.

Member: In view of your answer rather than limit a price clause to 10, 15 or 20 per cent increase, what attitude does the N.A.P.A. think of price increases reflected by actual costs of materials and labor that can be proved by the manufacturer?

H. E. Cross: Again as an individual expressing reactions I have heard among membership of the N.A.P.A., that we realize that in unsettled times where wages are variable and material costs are variable, there are bound to be times when those changing costs must be reflected in the price of the finished product. The majority of purchasing agents are reasonable men and in most instances where price changes are justified by changing costs, a mutual agreement on a fair price can be reached by the buyer and the seller.

Continuous Gas-Radiant Fusion FOR ELECTROLYTIC TINNING

By C. E. CUNNINGHAM
Selas Corporation of America
Philadelphia, Pennsylvania

. . . . the inverse-square law for radiation effect offers a rapid and accurate method of controlling the amount of heat to be transmitted, particularly in a continuous processing line . . . .

▲INLAND Steel Company's use of gas-radiation for continuous reflowing of as-plated tin, on the electrolytic tin-plate line at Indiana Harbor mill, is a process which not only accomplishes its original purpose but adds in a fundamental way to useful, industrial knowledge.

For practices of producing electrolytic tin plate, the method demonstrates the merits of radiation produced by high temperature, gas-fueled heat sources. The process offers new means of applying and controlling heat energy at high rates to meet prime yield requirements at fast, electrolytic tinning line speeds. Simplicity of the fusion equipment and its economy are outstanding.

For the field of metal heating, this method is best described by detailing the system itself, but a condensed statement can be helpful in a preliminary way. The method starts by utilizing radiant energy in such ample amount that heat is transferred to metal very rapidly. From this start, the inherent ability of radiation to modify its effect instantly and precisely with change of distance—the "inverse-square law" of our schoolbooks —is so put to work that the common lag of heat-control systems is canceled as an interfering factor. Need for heat in a variable metal mass moving at high speed, is linked essentially without time interval to the actual heat applied for the need.

This fast and essentially lagless performance makes the most of the natural speed and controllability radiant energy has always offered. In that respect, the tin-fusion installation at Indiana Harbor adds substantially to the record that radiant energy has earned in recent years during which metal producing industries have been seeking means of utilizing high-speed heating in integrated, precison-controlled processes. Engineering that has gone into the work and results obtained will serve as guides for other applications in which metal heating is to be done rapidly under most precisely controlled conditions.

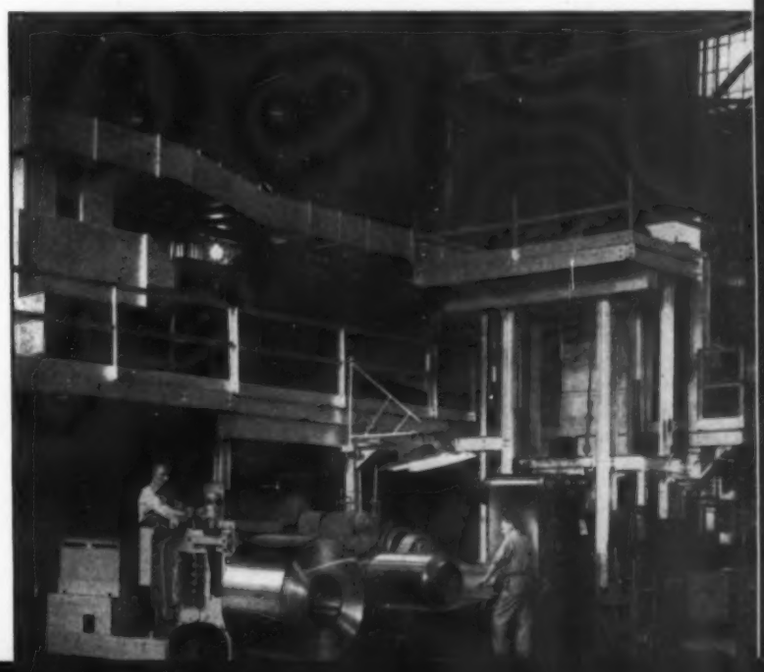
One notable item of the development, particularly interesting to process engineers, is that the project was completed on an electrolytic tinning line while the line was in production. To achieve a processing advance without interruption of a producing line is always a happy result, but in this case, as will be seen in the following brief review of the history, such accomplishment was necessary.

PRE-WAR CONDITIONS

Everyone familiar with tin-plate production in the United States knows that development and use of electrolytic tinning lines came in response to emergency conditions, accelerated by the tin shortage that arose at the beginning of World War II. It was absolutely necessary that tin be used in smaller quantities. More difficult still, it was necessary for the tin-plate industry to arrange, while saving on the amount of tin consumed, for greatly increased production.

Fortunately, the industry did not face war require-

Figure 1 — Delivery end of the present continuous electro-tinning line, showing location of the control station to the right of the coiler operator. The fusion panels are not visible but their location can be identified by the mixture-inlet piping visible at the extreme right of the photograph at the level of the top walkway.



ments wholly unprepared. Foresighted individuals among tin-plate producers had been attracted to the dual economy offered by electrolytic tinning. Not only did electroplating promise a vast saving by requiring as little as one-third the tin used per unit of tinned area by the long-established hot-dip method, there was the added promise of economical production by performing tin-plating operations continuously on high speed lines. Possibly the factor that stimulated pre-war thought and work, as much as any other, was the development and installation through the late 1920's and mid-1930's of continuous, high speed, cold reduction mills which could roll steel to tin-plate gages and widths. Controlled physical properties and improved surfaces provided by the new cold reduction processes, quite naturally suggested that high prime yield could be obtained from fast, continuous electrolytic tinning lines. Pre-war work with electrolytic tin deposit had brought definite knowledge that dull-coated or matte finish tin plate could be continuously produced with satisfactory yield. Equally important, the early work had given definite information as to the characteristics of electrolytic tin plate in resistance to chemical attack and in providing a suitable base for lacquer.

RAPID WAR-TIME DEVELOPMENT

When war came, this foreknowledge removed some speculative factors from the tin-plate situation, but the burden suddenly placed on the industry was both heavy and urgent. Hot-dip installations could produce tin plate and these could be added too, but the necessity of conserving tin turned efforts to thinner deposits and the need for more tin plate made higher production rates essential. The emergency project shaped in the direction of producing matte finish at high speed, doing this in a continuous line and doing it without taking time for pilot plants.

That the industry met the issue successfully and within short time was owing in no small measure to active cooperation which immediately came into being among tin-plate producers. Information based on prior and current work was freely exchanged. Arrangements for using patented elements for electrolytic matte production were quickly negotiated. Such exchange was of untold help in enabling producers to choose among several options for plating baths, anode designs, cleaning media and other line-elements. That, early in 1942, Inland was the first producer to have a plating line in continuous matte production was the result not only of Inland's own research but of the access Inland had to other studies and developments.

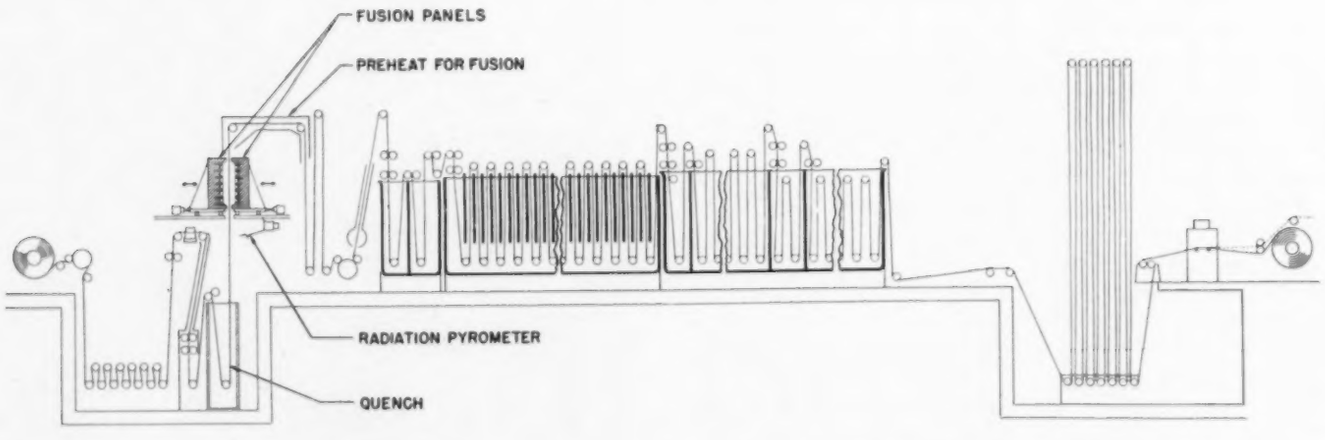
MELTING AND FLOWING MATTE-FINISH TIN PLATE

Although continuous production of matte tin plate was the first objective of the emergency project, work to provide a smooth, uniformly bright coating was being done. Facts available from earlier work showed that refinishing to produce a smooth, uniform surface offered further improvement as a base for lacquer and added to appearance, the latter being, of course, no unimportant factor for container manufacturers and for the canning industry. In taking steps to achieve bright surfaces, important early work was done in the tin-plate industry with mechanical brushing and with surface rolling.

The alternative to mechanical surface treatments was to use heat to melt the deposited tin and permit it to flow into a smooth, even coating.

Five principal ways of doing the heating presented themselves: (1) passing the plated metal through high frequency induction coils; (2) making the strip an electrical-resistance element by introducing current through contact rolls; (3) running the strip over heated rolls; (4) passing it through box type furnaces heated by conventional fuel-fired radiant tubes; (5) passing the strip through hot oil baths. In the whole record of how the tin-plate industry succeeded in meeting the emergency, it would be noted that each of these fusion methods played a part in greater or less degree. High frequency was developed to a thoroughly practicable means for high speed continuous fusion, as its present use on fast tin-plating lines in the industry well indi-

Figure 2 — Schematic diagram of the Inland electrotinning line indicates in scale the position and space occupied by the gas-radiant fusion system. Truck mounting of the radiant heating panels is shown with motor drive for moving the panels to and away from the strip to achieve vernier control of heat input in minutely exact relation to strip temperature.



cates. Electrical resistance was studied, and foreseen difficulties, principally with constant roll-contact and sparking, were remedied. With heated rolls, Inland was successful in the laboratory, though for reasons that will appear, Inland's choice went another way. Radiant tube furnaces were used by one producer who led the way into actual production of fused electrolytic tin plate, and another producer demonstrated that the hot-oil bath was practicable. But of all methods at hand at the beginning of the fusion development, only the electrical induction and electrical resistance methods offered speed sufficient for inclusion in a continuous plating-and-fusion line within reasonable and practical dimensions.

THE APPROACH TO THE FUSION PROBLEM

It is probable that Inland's development would have turned out to be no different from that of several other producers who chose to apply electrical fusion in high speed lines, had it not been for a fixed conviction that the basic approach should be as follows: In seeking to transfer heat very rapidly to speeding metal, the object was to think only of making concentrated, abundant energy available. The goal was "high temperature heat sources," and this was insisted upon for only with abundant, concentrated energy could the heating process be kept from impeding pace when integrated in the line.

The effect of this approach was crucial to the development. When concentrated, high power heat sources were the goal, radiant energy suggested itself and joined electrical energy as a possible medium. Development could then take place by choice of ways or by a combination of them, whichever was right for conditions of the work. Actually, the development started along the lines of combining high temperature gas-radiant heat with induction. Almost surely, had it started with induction alone, the innovations in the line would have been missed.

Inland, of course, had no aim at new discovery or innovation in developing a working line. The task was too serious and urgent, despite the fact that the plating line was in steady operation and was producing. The job was to fit fusion into the existing line, shaping arrangements as much as possible to local conditions in order to avoid delay. One of the local conditions was the relatively small space into which the fusion unit would have to fit, unless extra time were taken to rebuild at least a part of the line. Figure 1, which shows the delivery end of the tinning-fusion line, indicates how compact the heating unit for fusion unit had to be. The short, vertical space, at the extreme right of the photograph, between the middle and top walkways was available in the existing electrotinning structure. Effort to provide any greater space would have called for major design changes and delays for construction.

Another condition, quite favorable as things turned out, was the availability of a good supply of clean, coke oven gas.

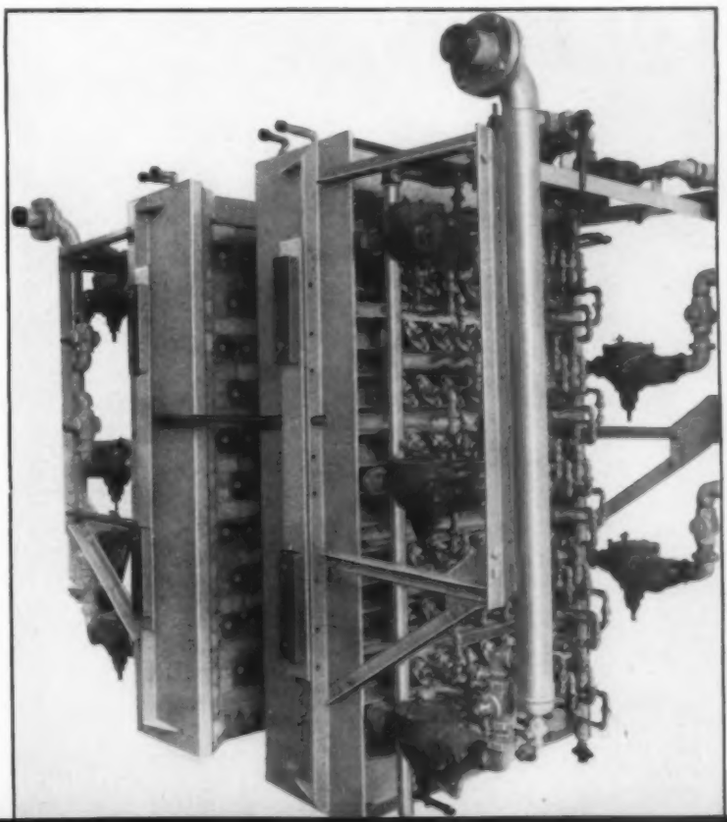
To save time by obtaining a clear view of fusion and thus avoid pitfalls, Inland made two studies concurrently. The first was to set up a method of studying the melting and flowing of tin as these phenomena occurred. An ingenious arrangement by which a motion-picture camera was joined to a microscope, enabled observations of reactions under controlled heating conditions by running and rerunning the films. The other study centered around high-frequency fusion. Inland developed and used, in a laboratory model, an induction system to test coil arrangements and to develop means of control.

From the microscopic-motion films and the induction trials, it was possible to identify and fix certain guiding factors. The desirable fusion temperature was confirmed (above the melting point of tin) at 470 degrees plus-or-minus 5 degrees F, a range that avoided oxidation and overheating. The benefit of a definite time factor between melting and quenching was noted and evaluated. As vital as any items of guidance derived from the studies, for ultimate operation under precision control, were two others:

1. An exact knowledge of the effect on fusion caused by variations in metal volume.
2. The value of having fusion occur in an unbroken line across the strip.

A third step was as simple as it was crucial. Early in the studies a demonstration of high temperature, gas-radiant burners at a national exposition pointed out that here was concentrated, high power energy. This show had the concrete effect of stimulating serious study of radiation from high temperature, radiant sources. Under Inland's direction, Armour Research Foundation set up a roll system heated with gas-radiants inside. By thoughtful use of chromium plating on

Figure 3 — Photograph of present gas-radiant heating panels, taken prior to installation, shows panels facing approximately as in service with space between for vertical passage of continuous strip. Design of the gas-radiants and their nesting provide for removal of any radiant element at the back of the panel. Manifolds permit shut-off of radiants at sides to adjust for strip width.



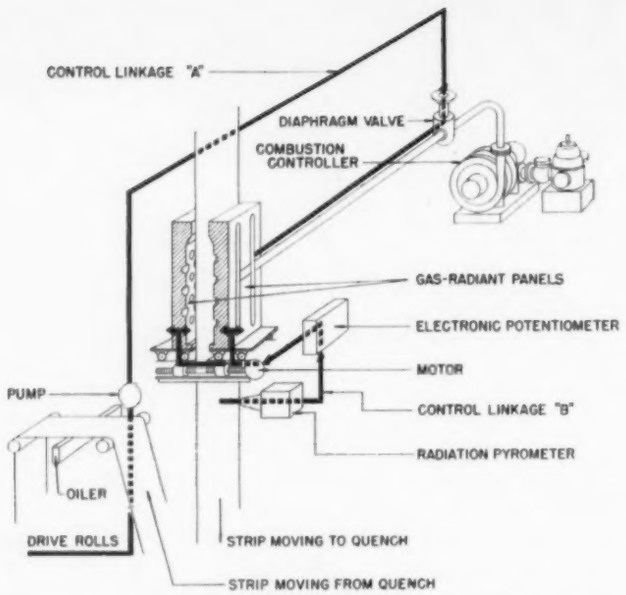


Figure 4 — This diagram shows schematically how strip temperature control is achieved with vernier accuracy and with response so nearly instantaneous that the tin coating consistently melts at a given point in its high speed passage through the heating panels. Such control is made possible by dividing control functions into two integrated systems, identified in the diagram as control linkages "A" and "B." "A" has the function of throttling fuel input to the heating panels in precise relation to line speed. Rotation of one line-roll drives an oil pump and causes oil-pressure to change directly with line speed. These pressure changes are transmitted to a diaphragm valve in the fuel-mixture line which feeds the gas-radiant panels. "B" has the function of moving the radiant panels to and away from the passing strip. Fine, incremental movements, applying the inverse-square law governing the effectiveness of radiant heat, are made in direct response to strip temperature as it affects a radiation pyrometer. The pyrometer is linked to an electronic potentiometer whose impulses are immediately employed to cause motor-rotation and thus adjust panel position.

the heating roll, tin was successfully fused with no damage whatever to tin surfaces from roll contact. Although the roll system was abandoned in favor of a simpler use of radiant heat, the work contributed directly to the choice of energy-sources in the first fusion unit designed for the Inland line.

FIRST PRODUCTION UNIT

Data developed in the studies came to light rapidly, and little time was lost in translating the findings into a working design. By early 1943, Inland was fusing on the production line without having stopped to make more space available for the operation.

Details of conclusions and decisions that influenced the first design have value not only as a review of the development but as showing certain merits both of high-gradient radiation and induction. The items in the thinking can be summarized briefly:

1. High temperature gas-radiants lend themselves to assembly in a pattern by which heat can be widened or narrowed by simple throttling.
2. Heat generated within incandescent sources at surface temperature of the order of 2850 F, offers concentration for compact space, high potential for rapid transfer and quick response to changes in fuel input.

These merits plus the immediate availability of gas stimulated development of a combined unit in which high gradient radiation would function to preheat tin plate to near the fusion temperature. With this arrangement, a high frequency induction coil could be used as an accurate, instantly responsive controller for final fusion. The induction coil and necessary electrical equipment could be small and more readily acquired and installed.

There were other merits in the idea of a combination unit, two of which were forerunners of the finally developed control system. Fuel input to the gas-radiant panels could be throttled accurately to line speed by a tie-in to a diaphragm valve, a pump-actuated system which we had developed and applied for other high speed heating processes requiring prompt input control. By this responsive control of preheat, control at the induction coil would be reserved for the function of correcting heat input in response to variations in strip thickness. The purpose of separating the control functions was not only to hold temperature within the desired, narrow range but, for the sake of quality, to hold the line at which melting took place at a prescribed distance from the quench.

In the first unit, field intensity of the induction coil was to be regulated by two photocells, one above the place at which melting occurred and one below. They were arranged to be responsive to the position of the reflowing line on the strip.

The second provision that proved crucial later was a simple arrangement for moving the gas-radiant panels away from the tin plate when the line was stopped and for manually adjusting distance between the radiant panels and the strip when strip-gage on the line was to be changed. Earlier work with gas-radiants had shown how precisely true the old "inverse-square law" was, in that metal as thin as strip steel could be protected from overheating, and heat transfer could be accommodated to heat-absorption capacity by retreating and advancing panels a short distance. This first provision for panel movement led to success in vernier control of radiant heat.

Line speed with the first fusion unit was of the order of 300 fpm. It was by no means an experimental arrangement, for it worked and prime yield was good, but as with first units in many fields, its chief mission was that it led directly to further improvement. Before the unit had operated more than a few days, two observations were made that started new thinking.

The two observations made in early operation of the fusion unit can most clearly be seen by examining the diagram of the present line, Figure 2. It will be noted that the strip approaches the preheat panels through a duct and, in turning to move vertically, passes over a roll. The main purpose of the duct originally was to pass combustion products from the radiant panels so that an envelope of burned gases covered the oncoming strip to preheat it while avoiding oxidation. The function of the roll was only to guide strip movement.

If the hot convection gases and the roll had perform-

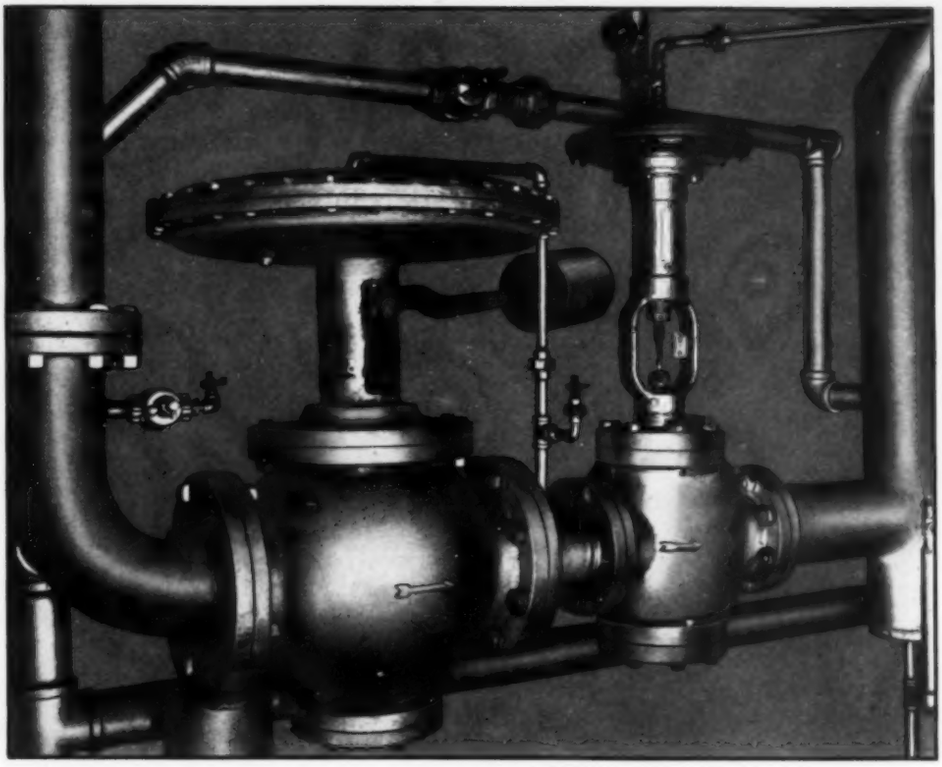


Figure 5 — This valve arrangement in the fuel-mixture line throttles input to the heating panels in exact relation to strip speed. Entering the photograph at the extreme upper right is small piping. Fluid pressure in this pipe exactly reflects the speed at which strip is moving in the electrolytic tinning line, and the pressure affects the diaphragm valve to which it is shown connected. Thus valve position is governed by strip speed at all times, and flow of mixture for combustion is governed likewise.

ed only their intended work, the fusion unit would probably have been kept to the ideas of the original combination design. The fact was that some extra work was being done with effects that first looked like trouble. The operators, watching the line at the fusion station, saw at once that fusion was starting not at the induction coil but within the radiant panels. This was the first seemingly bad result. The second was that the fusion line instead of running straight across the tin plate was taking the shape of a sagging string, a rounded "V".

What was happening was quite plain. Heat from convection gases was passing into the tin plate at the edges. The exposed roll ends (not contacted by the moving strip) were storing enough heat to add to the edge-heating effect. In addition, the duct was causing enough preheat to turn the radiant panels into a fusion station. The induction coils had next to nothing to do.

It should be repeated that the installation was functioning and giving good prime yield. Some bluing effect was noted where edges were overheating but this was quickly remedied by arranging to water-cool the roll ends.

This change to roll-end cooling had a double effect. Not only did it stop edge bluing; it caused the sagging fusion line to move closer to the desired horizontal. Straightening the line was the crucial benefit. It gave the prospect of a totally satisfactory fusion result. It was then decided to rely wholly on high-temperature gas-radiant heat sources.

FACTORS IN DESIGN OF GAS RADIANT FUSION UNIT

The two main purposes that guided design of the all-gas fusion unit were to make more radiant heat available for an increase in line speed and to make further use of the control advantages identified in the operation of the first unit.

For speed of fusion in short space, the first unit was witness that radiation had power to complete the action of fusion at any line speed. Gas-radiant designed by our company permitted close nesting in concentrated, high energy panels.

Figure 3 shows the present heating panels and illustrates the close nesting of gas-radiants.

For control, operating and studying the first unit contributed five successful features to the second:

1. Tie-in of gas input with line speed and strip section by automatic operation of a diaphragm control valve.
2. End cooling of the roll immediately above the radiant panels to provide against edge effect and to allow for changes in tin-plate width.
3. Simple provision for additional control of edge-heating by arranging to throttle radiants at the sides of the panel.
4. Preheat in known amount by conducting hot products of combustion through the incoming duct.
5. Provision for moving panels to or away from the tin plate in event of line shut down.

To these features was added another in the interest of holding the fusion line horizontal, of causing the line to remain within a narrow predetermined zone and of effectively sealing the panel end from inrushing air. The idea was to place two ribbon burners below the exit ends of the panels, one on each side of the strip. These burners were capable of sending out a high pressure stream of extremely hot combustion products with emission temperatures of the order of 3000 F. For adjustment to tin-plate widths, the flow of combustion products could be readily narrowed or widened, and for controlling the shape and position of the fusion line, the angle of heat impact on the tin plate could be changed,

according to observed need, by rotation of the burner bodies.

Such a unit was built and put into operation. The line speed was stepped up to 400 fpm and again prime yield was good. But the greatest result, was that this all-gas fusion unit brought the operators to the point of new discovery.

In seeking improvement in metal processing, better prime yield and greater tonnage are often, if not always, main goals. Here, the first all-gas fusion system was a going unit doing well. Relatively simple design changes to give greater radiating energy could permit line speed to rise further. In fact, the effectiveness of radiation could more than keep pace with plating and other line operations.

But was greater fusion speed the first step to take, since radiation-fusion essentially had no speed limit? Such questioning in the development was invited by a basic fact, namely that the control system had successfully separated major, automatic adjustment for line-speed and strip section from adjustment for minor variables, such as strip thickness variations. This separation was contributing so well that the desire arose to make the thickness variation adjustment automatic and thus enable panel-movement to give continuous correction for variations in heat requirements of the strip.

Experience in operating the fusion unit supported this desire. Operators observing the tin plate as it emerged from the radiant panels had learned that by making slight changes in distance between strip and panels, fusion-action could be modified. Even though the distance-changes were made manually, they contributed noticeably to further improvement in uniform product.

There was still another factor in wanting to make panel-distance corrections automatic and continuous. Discussion of panel-movement as a means of control had arisen very early in the development and now was revived with several options presenting themselves. It had been known all along that radiation-distance could be coordinated with line speed and that the equipment designed for such control was operating successfully in other fast heating applications. However, in this case since the factor of line-speed was already cared for, little was to be gained.

The fact that strip thickness was one of the variables determining the amount of heat absorbed by the strip, gave rise to the possibility of coordinating thickness directly with panel-distance. To pursue this, however, was a matter of seeking appropriate means of measuring extremely small thickness variations continuously and of translating the measurements into extremely rapid and fine panel response. It was a matter of instrumentation. But since thickness was but one of several variables affecting heat absorption, why not turn to the one resultant of all the variables, in other words to the tin-plate temperature? Admittedly, such a project was also a matter of instrumentation and well beyond the limits of established instrument performance, but if means could be found of using temperature for the purpose, the problem would indeed be well solved. The decision was to try.

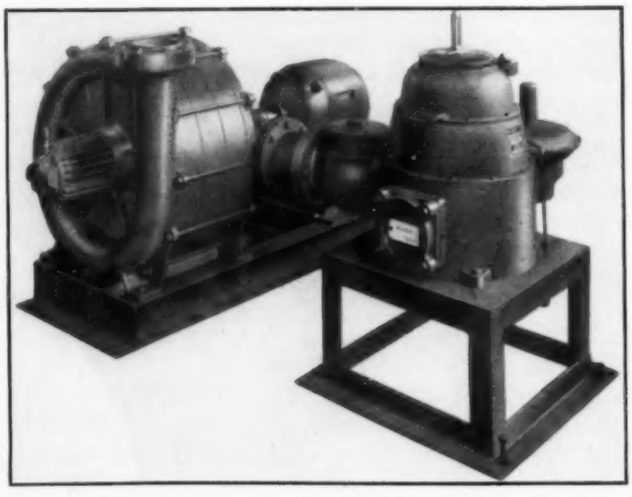
The time interval within which a panel-movement-control system would have to operate was readily calculated. At a nominal speed of 500 fpm, a given point on the strip would move through the 8-foot panels of the fusion station in just less than one second. The principal objective of holding the fusion line to a predetermined, narrow space within the 8-foot panels reduced this allowable time to a small fraction of one second.

If this could somehow be done, the high-pressure superheat burners at the exit end of the panels could return to the simple task of sealing the strip channel from air inrush, and the panel movement could take the sole responsibility of adjusting radiation in simultaneous relation to final variables capable of affecting temperature of the tin plate as it approached the desired point at which fusion was to occur.

To seek the answer, Inland took the natural step of talking with instrument makers and in doing so chose a company which had contributed extensively in developing temperature pick-up instruments capable of immediate response to radiation. At first the company representatives demurred. Their radiation pyrometers were intended to pick up and respond spontaneously to radiation in the form of heat. What Inland sought to do was to pick up temperature from surfaces that emitted not only heat waves but light waves in great amount from smooth, brilliant tin.

The thought occurred: why not shield the pick-up device and this was tried. A radiation pyrometer was installed and shielded so that only the waves from a restricted source could affect it. Then the impulses were wired to a standard electronic potentiometer which, in turn and without delay, energized the motors of the panel-moving arrangement. This was the first step. The potentiometer was prepared to take "readings" of the strip only at 2-second intervals but the tangible results were all that could be expected. There was an immediate, further improvement in prime yield. Beyond this was the far-reaching contribution in joining for control purposes the actual temperature of metal during a heating operation to the well-behaved "inverse-square law."

Figure 6 — Combustion controller of the kind used to provide controlled gas-air mixture for the heating panels. The bell-like structure at the right has air inlet in the foreground (identified by a tag) and, in back, gas inlet through a gas governor. Mixture with controlled gas-air ratio is piped to the turboblower at the left in which the mixture is compressed for delivery to high pressure gas-radiants in the heating panels.



The final step was a simple one. Because this process required a control system having unusual sensitivity and speed of response, with the cooperation of the instrument engineers, the first potentiometer was replaced by another, the latter capable of repositioning at all times instead of waiting, as the first potentiometer did, through 2-second intervals.

The result was that the radiant panels moved toward and away from the strip in a kind of exact "breathing" action. To see it, is to see temperature input directly tied and immediately responsive to change in heat need. Changes in radiation effect, represented by incremental movement of panels through fractions of an inch, are taking place in direct and absolute response to tin-plate temperature, compensating among other factors for variations in strip thickness that range in thousandths of an inch.

CONTROLLING RADIATION EFFECT

In reviewing the history of the development, Inland gives credit to the insistent concept of radiation as a powerful source for fast heating. To them, a heating agent whose effectiveness varies directly as the fourth power of absolute temperature is a heating tool to be exploited. To fit this contribution into the proved behavior of radiation requires but a brief summary of other accomplishments. Our company, in pioneering with high temperature, gas-radiant heat sources, had shown four main ways in which high-gradient radiation lent itself to fine control at high production speeds. Inland reduced the fourth method to practice with controlled accuracy hitherto thought impossible.

Following are three examples of different basic types for radiation control, cited from production applications of fast metal heating and heat treating. All depend on having an abundance of radiant energy in the form of a high heat-head so that work can be rapidly moved to, through and away from the heat source.

1. *Bar and tube heating*—Here radiant energy can be represented in the form of a central body. This body envelopes single work pieces as they are conveyed through it. Sections of different sizes can be passed through the heat without change of heating structure.

Control here is by time-of-passage, by temperature change, or by combination of both, whichever best meets conditions. Response to adjustment for time-of-travel is extremely quick. So is response to temperature adjustment. In one installation, now heating steel tubes ranging in section from 2½ to 6½ inches outside diameter, and from 0.134 to 0.625 inch wall, with tube travel up to 60 fpm, effective heat can be changed as much as 500 F before the charge has moved one foot. Control of this kind of heat scheme can be and usually is wholly automatic.

2. *Through heating of irregular shapes*—For this application, control starts with a pattern of radiant heat sources arranged in relation to the mass-distribution of the work piece. For an automotive connecting rod blank, as an example, two walls of a tunnel are studded with high-temperature gas radiants in such a manner that heat is transferred in proportion to mass as the work is traveled past the pattern.

With pattern control as a basis, speed of heat transfer can be precisely adjusted automatically or manually by speed of passage, input throttling or a combination of both.

3. *Selective heating*—When only a chosen portion of a blank or other work piece is to be heated, control starts with arranging a special shape of the gas-radiant orifice, as when only the wearing surfaces of plier jaws are to be hardened, or with special grouping of gas-radiants as in selective, high speed brazing. In either case, fine control of heating effect is accomplished by adjustment of exposure time or of fuel input.

To these three sets of heat-control conditions, the Inland fusion arrangement adds the fourth—the movable heating wall. Here control had its start in pattern of the gas-radiants. From this start, minutely fine and almost instantaneous control of heat effect was gained by separating control of fuel input from control of radiation distance. After input had been tied to line speed, panel position provided the ultimately fine and rapid adjustment.

DIAGRAM OF FUSION CONTROL

Figure 4 has been made schematic and captioned for the purpose of showing most clearly the integrated elements of control as identified in preceding text. However, there are five items that deserve special comment.

It will be noted that the radiation pyrometer is located below the exit end of the panels. Immediately this should suggest that adjustment of panel position is taking place after the portion of tin plate which needs adjustment of heat effect has passed through the heating station—that the barn door is being closed after the horse has been stolen. The noting of one major condition, however, shows why the radiation pyrometer is well located and how the control is able to function. It should be recalled that the purpose of distance correction is not to complete the fusion reaction but to adjust the position of the line at which fusion occurs. Fusion takes place within the panels; the panel-position-control determines exactly where. In order to adjust line-position, temperature pick-up can be arranged at any strip area which has been subjected to the total heating effect prevailing at a given moment. The convenient place to make such pick-up is at the panel exit.

The second item worthy of comment has to do with stabilizing the conditions under which the pyrometer functions. Note has already been made of the shield around the sighting tube which properly restricts the scanning field. In addition, a water-jacket has been placed around the instrument body to hold body temperature to approximately 120 F. The melting point of tin is used as a calibration point.

The third item has to do with the means by which fuel input is tied to line speed. Figure 5 shows a pressure regulator (left) and immediately to the right of it a diaphragm valve, both located in the gas-air mixture line feeding the gas-radiants in the heating panels. An oil pump is directly driven by a roll over which the strip is passing. Pressure of the oil, which varies directly and continuously with roll speed, is applied to the diaphragm valve and causes direct and immediate change in fluel flow. The oil pressure, and therefore the fuel

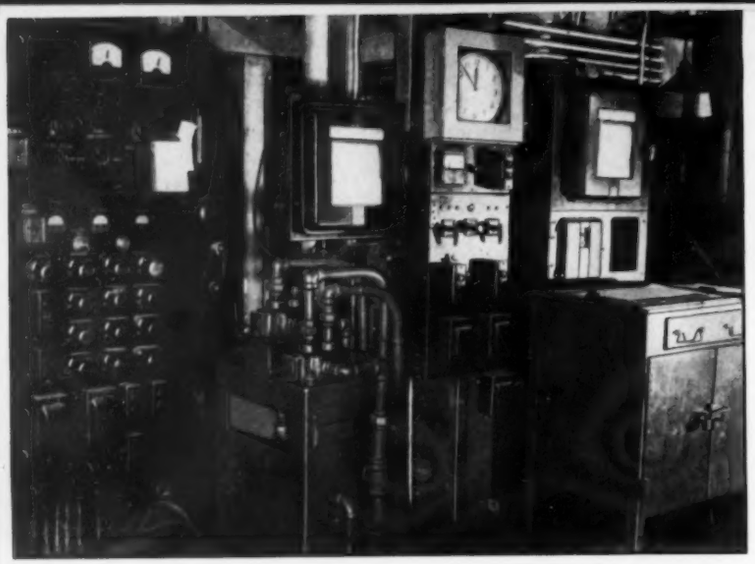


Figure 7 — Control station for the electrolytic tinning line indicates the relative simplicity of operations.

flow, at any speed can be set for any given cross section of the steel by bleeding oil from the high pressure to the low pressure side of the pump.

The fourth item has to do with the combustion controller which provides the gas-air mixture. Engineers familiar with the basic method for high-speed, radiant heating will recognize the fundamental part combustion controllers play in making high-temperature, gas-radiation available for fast-heating applications. To produce abundant radiant energy, calls for maintaining exactly at all times, for all rates of fuel input, a predetermined ratio of gas-air combustibles. It is equally essential that the selected mixture be compacted or compressed so that combustion can take place at high rates. A combustion controller of the kind used for the Inland fusion panels is shown in Figure 6.

It should be noted that this speeding of the combustion rate does not add to total fuel consumption. So much active radiant heat is made available that heat transfer is itself greatly speeded and the process is completed in shorter time and, therefore, with less aggregate fuel.

The fifth item has to do with the design of the gas-radiants and the materials of which they are made. Performance of the panels, the factor that makes possible extremely rapid heat transfer and the lagless control, rests squarely on the fact that so much of the heat created and liberated is in the form of radiant energy. To provide it, the compacted, controlled fuel mixture delivered by the combustion controller is introduced into cup-like chambers for ignition and complete burning. The chambers, made of ceramic materials, are brought to incandescence and with this incandescence comes abundant radiation.

The nature of the ceramic materials and the design of the radiation-cups are critical in producing heat which contains radiant energy in large amounts and in giving a proper burner life for high-temperature operation.

RELATIVE COSTS OF HIGH-SPEED GAS-RADIANT HEATING

Inland's experience with installation, operation and maintenance of the gas-radiant fusion system, offers evidence in support of experience elsewhere that the gas-radiant process is in a very favorable position in the vital matter of costs. Actually in the wartime emergency, Inland would have been thoroughly justified in employing any of several options to get the line in production and to include fusion in it. Cost could well have been a secondary consideration. Test of the matter of cost, for the gas-radiant equipment, for running it and maintaining it, is probably best seen in present plans. Cost factors with the existing unit have been of such level that Inland is proceeding with a new gas-fusion installation.

Aside from relatively low equipment and operating cost, it is noteworthy that maintenance has been so small as not even to appear in the time records for the maintenance crew in the entire period from early 1943 when the first gas-fusion unit went on the line.

To the favorable cost factors, the ability of the gas-radiant system to fit into comparatively small space should be added.

When this development of continuous, gas-radiant fusion is weighed for its full importance, the most striking value is that it goes beyond the act of fusion itself. A moment's reflection about the steel industry's recent efforts with respect to continuous, in-line processing indicates that a serious, even a vital trend exists and that this contribution in this latest development fits into it. The trend is to take full economic advantage of straight-through, high speed, automatic processing.

Technologically, successful utilization of high temperature radiation gives the tin-plate industry a choice of methods when installations are being planned for continuous, straight-through production on an electrolytic line. It raises high-temperature radiation to a plane at which selection of induction heating or radiation can be made by comparing known performance factors. Thus choice can be for the method or combination of methods best fitted to local conditions. In this technological respect, Inland gas-radiant fusion takes its place with Inland's well-known contributions to improvements in continuous sheet and strip production and to metallurgical and surface qualities of hot rolled and cold-reduced product.

The trend of engineering thought current in the industry increases technological values. Straight-through practices, which contributed so greatly with hot sheet and cold strip production, are being investigated and applied in processes that range from the first steps of steelmaking to final stages of metalworking. The human energy going into these investigations, the designing of pilot operations and the introduction of physical changes in plant speaks for what is almost certainly the broadest and most vigorous action to improve processing the industry has ever undertaken.

In this effort, heating processes are being examined with new candor. Fast heating is being asked specifically what it can do to help integrate production lines and cut deeply into the huge expense that slow heating and separate handling have conventionally involved. This contribution, in adding to the record of high temperature, radiant heat, is thus a part of the industry's total effort to bring costs and prices within proper bounds.

STEEL MILL APPLICATIONS OF *Electronic Control*

. . . . it is expected that, in the future, electronic applications will become widespread in the steel plant . . . . in many cases, electronic control offers a more simple design than conventional equipment . . . .

By J. RAYMOND ERBE
Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

▲ IN this paper, our aim will be to present several electronic applications which are now in operation in the steel industry. We will describe these in a non-technical manner.

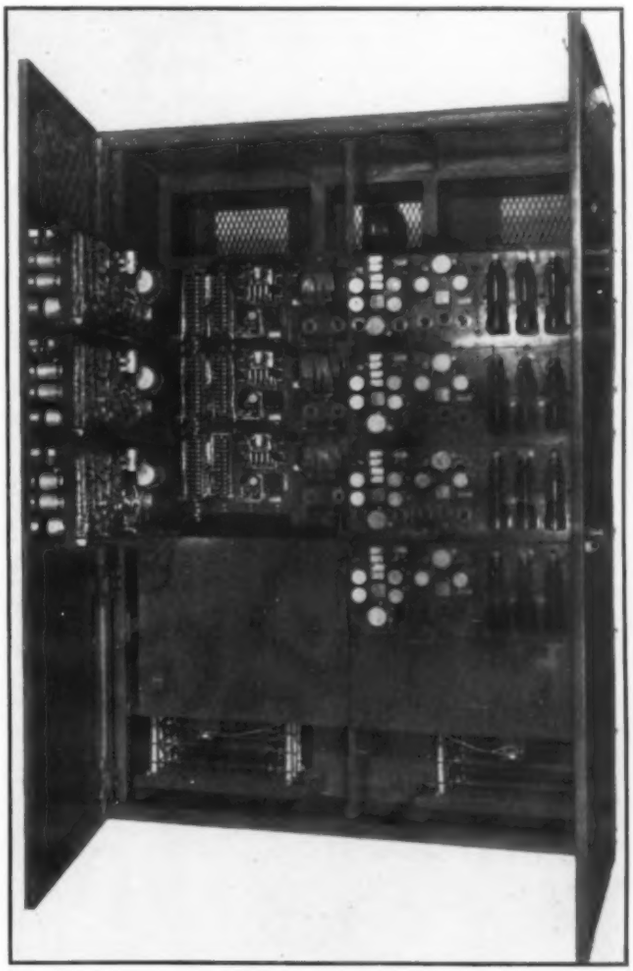
Since electronics is still in its infancy, it has many possibilities which have yet to be explored. Because electronic control made its advent almost simultaneously with the birth of radio broadcasting, it is only natural that electronic control equipment had many points in common with that used for radio purposes. In most cases, the actual apparatus was identical.

Realizing that the type of service encountered in industrial applications is much more severe than that normally required for radio use, we have re-designed our electronic control equipment in accordance with accepted industrial practices.

As every electronic control can be separated into several functionally different units, we have designed each of these as an independent sub-assembly on its own chassis. These are then produced separately and stocked for use as required. In making any specific electronic control, it is only necessary, in most cases, to determine which of these various sub-assemblies are required and mount them in a suitable industrial type, either floor or wall mounted, self-supporting, sheet steel cubicle. Figure 1 is a photograph of a complete control built up in this manner.

With this arrangement, as seen through the opening where the sub-assembly is swung out for inspection, the connections from each unit are made to suitable terminal blocks in the rear of the cubicle by means of flexible leads with plug connectors. This permits bringing all of the external wiring into the rear of the cubicle and permanently connecting it to the proper terminal blocks. It also facilitates removing or replacing any sub-assembly since it is only necessary to remove the plug connectors and detach the sub-assembly to completely remove it from the cubicle. With this arrangement, the entire sub-assembly can be removed for any repairs or modifications, and these can be made wherever most

Figure 1 — This photograph shows an electronic motor control made from typical sub panels. The left hand group of panels is shown swung out for inspection. The top center panel shows a typical field control panel. The group of sub panels on the extreme right are typical armature control panels. The row on the extreme left is a typical electronic control panel.



Presented before AISE Chicago District Section Meeting, January 6, 1948, the AISE Cleveland District Section Meetings, January 19, 1948 at Cleveland, Ohio and January 20, 1948 at Youngstown, Ohio.

Figure 2 — This photograph shows the strip as it enters the pinch roll of an anneal and pickle line. Although only two strands are being run in the picture, the line is built to handle three strands simultaneously. Each strand has its own pinch roll driven by a 7½ hp 230 volt, 850 rpm, shunt wound, d-c motor with drip-proof semi-enclosing covers with motor mounted speed indicating generator.

convenient. The entire sub-assembly can, if desired, be taken to the electric repair or maintenance shop. It even permits, if so desired, the substitution of a spare sub-assembly in the event that the user has such a spare sub-assembly in his stock.

In making this transition from radio type apparatus to the industrial type, we have changed from the use of the dry paper type capacitors used in radio work to a non-inflammable insulating liquid impregnated capacitors. The use of telephone type relays has given way to the use of standard industrial relays. Volume control type of rheostats and potentiometers used in radio have been replaced by heavy-duty industrial type devices. In addition, the various tubes are not worked as near their peak ratings as formerly, with resulting increased tube life. These, with numerous other such changes, have greatly improved the performance, increased the dependability, and reduced the maintenance required for this type of apparatus.

A typical application of this type of control is the electronic motor control supplied for several anneal and pickle lines. These lines have an operating speed of from 4 to 32 feet per minute. This speed must be closely maintained so as to keep the loading of the annealing furnace uniform in order to obtain proper annealing of the strip. Figure 2 shows the strip as it leaves the scrubbers and enters the pinch roll. Although only two strands were being run in this line at the time the photograph was taken, the line is built to handle three strands of strip simultaneously. Each strand has its own pinch roll driven by a 7½ hp motor complete with a motor mounted speed indicating generator. These pinch rolls furnish the power to pull the strip from a coil box or uncoiler through the pickle tanks, annealing furnace, and scrubbers. Electronic motor control was used to supply power for these pinch rolls thus providing con-

Figure 3 — This photograph shows the delivery end of the line from the drive side showing the reel motors and the air ducts which provide the air for force-ventilating the motors.

version from the plant a-c power supply to the d-c power required for driving the motors. The control was arranged so that the pinch rolls closely maintain their preset speed irrespective of the load. In this case, the line speed range is obtained by armature voltage control.

Figure 3 shows the delivery end of the line from the drive side showing the reel motors and the air ducts which provide the air for force ventilating these motors. Figure 4 shows the reels from the operating side of the line. These reels are arranged for either winding over or under as desired. Each reel is driven by a 7½ hp, 850/

Figure 4 — This photograph shows the reels at the delivery end of the line. These reels are arranged for either winding over or under, as desired. The coil build-up is compensated by controlling the reel motor to maintain constant strip speed. The output of a speed indicating generator driven by the guide roll ahead of the reel is used to provide the intelligence for the electronic motor field control to change the motor field as the coil builds up. Each reel is driven by a 7½ hp, 230 volt, 850/2125 rpm, shunt wound, d-c motor arranged for forced ventilation. The shear, for cutting out the welds, can be seen in the background. The operator's control desk, from which the entire line is controlled, can be seen at the right.

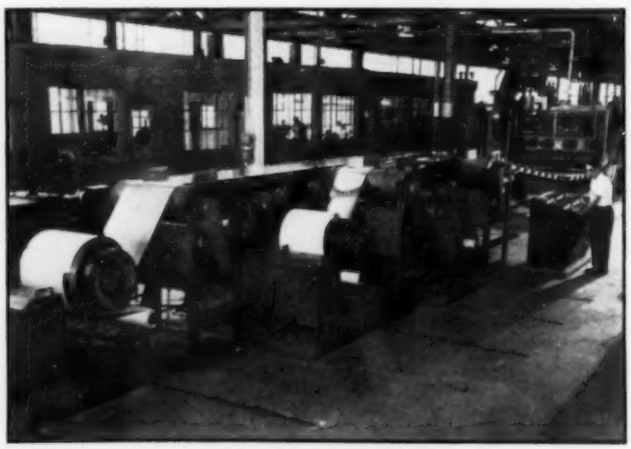
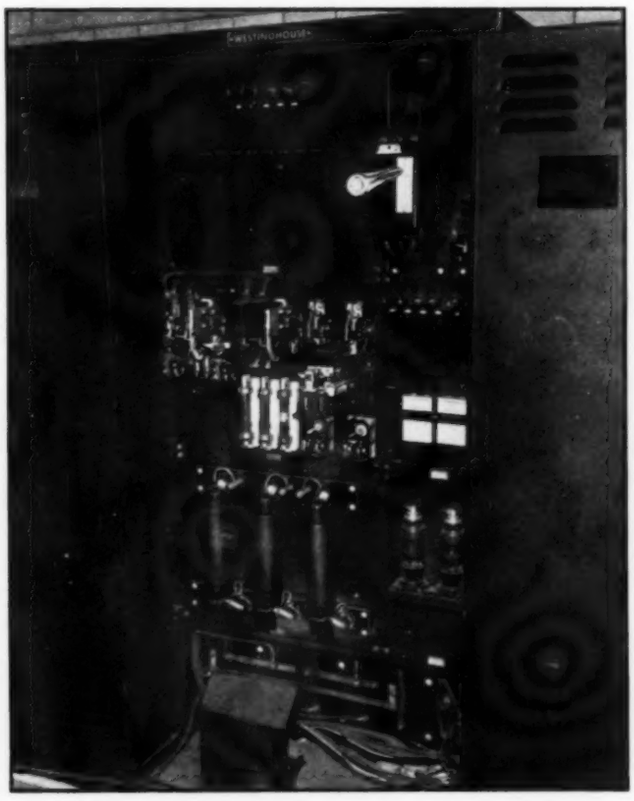


Figure 5 — Shown here are the control cubicles for the electronic control for three anneal and pickle lines. There is a similar row of these controls on the right hand side of this same control room. Part of a control center, containing the linestarters for the a-c motors, is visible in the left foreground.

Figure 6 — The panel arrangement of one of the electronic motor controls used to control the pinch roll and reel drives on these lines is here shown. At the upper right can be seen the air circuit breaker for the a-c incoming power supply. In the center can be seen the overload relay, reversing contactors, sequencing, and timing relays. At the lower left are the ignitron rectifier tubes which provide the armature supply for the motors. At the lower right are the thyratron tubes which provide the motor field current. At the extreme top of the panel just below the circuit breaker can be seen the control tubes. At the extreme left bottom can be seen the blower which provides the forced ventilation for the cubicle.



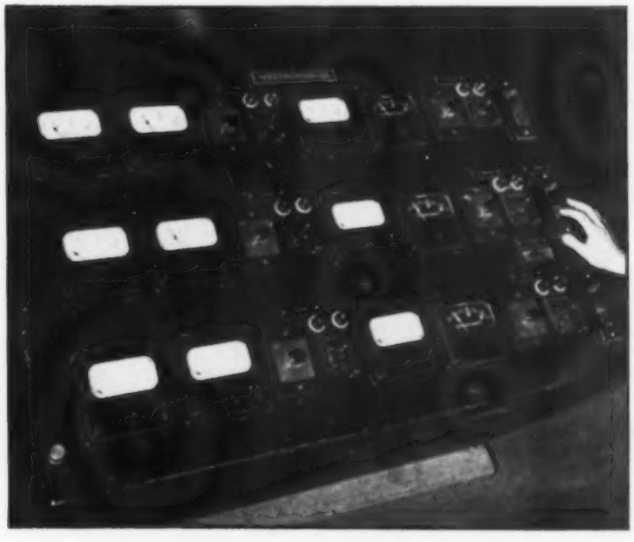
2125 rpm, d-c motor arranged for force ventilation. As in the case of the pinch rolls, the strip speed is again obtained by armature voltage control by means of electronic motor control. The coil buildup is accomplished by controlling the reel motor speed so as to maintain constant strip speed. The output of a speed indicating generator driven from the deflector roll ahead of the reel is used to provide the intelligence for the electronic motor field control which changes the motor field as the coil builds up and thus automatically compensates for the change in coil diameter.

Figure 5 is a photograph of the control room which shows the control cubicles for the electronic motor control for three of these anneal and pickle lines. There is a similar row of these controls on the right hand side of this same control room facing those shown in this picture.

In Figure 6, the doors of one of these electronic motor controls were opened and a photograph made showing the panel arrangement used for controlling the pinch rolls and reel drives on these lines. At the right can be seen the air circuit breaker for the a-c incoming power supply. In the center can be seen the overload, sequencing, and timing relays. At the lower left are the metal enclosed thyratron tubes which provide the armature supply for the motor. At the lower right are the thyratron tubes which provide the motor field current. At the extreme top of the panel and just below the circuit breaker can be seen the control tubes. At the extreme bottom can be seen the blower which provides the force ventilation for the control cubicle.

Figure 7 shows the operator's control desk, for operating this line, with the reel ammeters at the extreme left, next the reel speed indicating meters, next the speed control rheostat for the reels, next the control switches for starting and stopping the reels. Further to

Figure 7 — This photograph shows the operator's control desk with the reel ammeters at the extreme left, next the reel speed indicating meters, next the speed control rheostats for the reels, next the control switches for starting and stopping the reels. Further to the right, in the same order, are the same controls for the pinch rolls. At the extreme right are the pushbuttons for the linestarters for the dryer fans and scrubber motors.



the right, in the same order, are the similar controls for the pinch rolls. At the extreme right are the pushbuttons for the a-c linestarters for the dryer fans and scrubber motors.

It is interesting to note at this time that for these lines using electronic motor control, the electrical equipment was approximately 10 to 15 per cent less expensive using the electronic motor control than it would have been had similar control been provided using standard variable voltage equipment in combination with the necessary magnetic control.

Shown in Figure 8 is a fundamental schematic arrangement of an electronic motor control of the type used for these lines. This drive consists of a direct current shunt wound motor whose field and armature are supplied by thyratron rectifiers. These rectifiers are so controlled as to vary the input to the motor, regulate the motor speed to a preset value, and limit the maximum current furnished the motor during acceleration and reversal. A control of this type permits smooth control of the motor over a speed range of as great as 20 to 1 below the base speed of the motor by means of armature voltage control, and over an additional field control range of as much as 4 to 1 above the base speed of the motor. Speed control over the 80 to 1 range, that is the entire range, both below and above the base speed of the motor, is obtained by means of a small potentiometer rheostat such as those seen in Figure 7. Combined with this wide range of speed control is a very flat speed-torque characteristic over the entire range. This is obtained through the use of speed regulating circuits which insure that the motor will be held to the preset speed chosen by the operator. In a properly adjusted system, the speed over a range of 10 to 1 by armature voltage control, below the base speed, will not vary more than 4 per cent from the preset value, even with the torque varying from no load to full load, nor will it vary more than 8 per cent for any speed within the speed range of 20 to 1 previously mentioned. Due to the nature of the circuits used in a control of this kind, variations in the alternating current voltage supply have only a minor effect on the speed regulation.

Figure 8 — This is a typical schematic arrangement of a complete electronic motor control showing the motor field and armature being supplied by suitable rectifier tubes directly from the a-c power supply and the entire drive being controlled electronically by means of suitable electronic control panels.

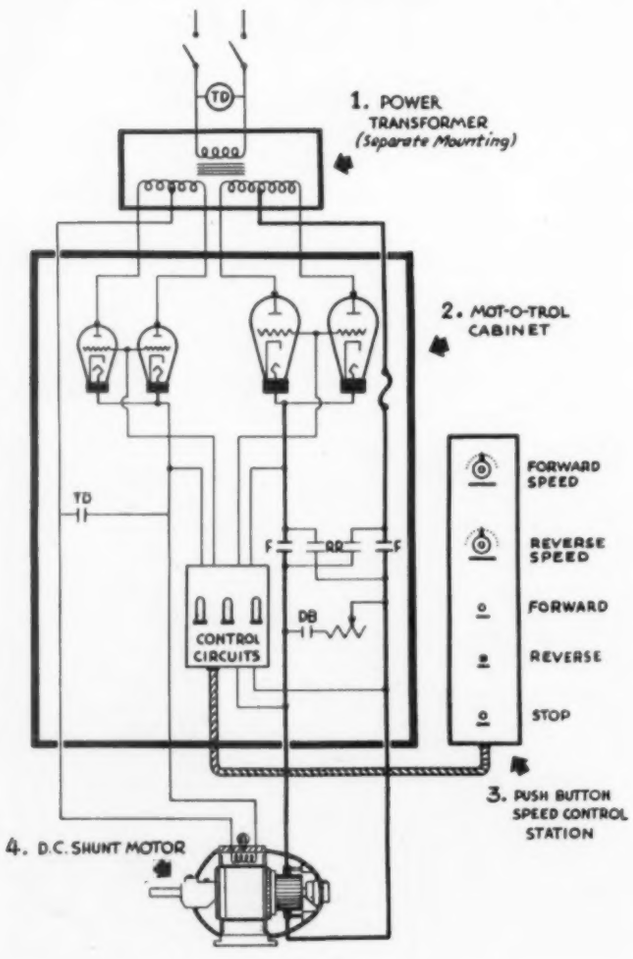


Figure 9 — A typical application of photo-electric control on a shear. The photo-electric relays are used to interlock the shear so that it will not operate in case any part of the operator's body interrupts the light beam indicating that he might possibly be caught in the shear.

Several other interesting electronic applications fall in the category of photo-electric control, in which the basic intelligence for the control is obtained in the form of light.

One of the simplest applications of this type is the use of a photo-tube and a light source in combination with suitable amplifiers and associated apparatus, such as a flag switch to initiate the starting of a flying shear. Similarly, in a recent hot strip mill, a photo-electric control of this type is used to automatically turn on the de-

Figure 10 — Electrolytic tin plate being fed into a 600 fpm shearing line. A 7½/10 hp, 50/200 rpm output, 230 volt, d-c gear motor in the lower left operates a cone type uncoiler. Length of loop between uncoiler and shearing line is automatically maintained electronically. A 50 hp, 850/1700 rpm, 230 volt, d-c motor in the rear of the pedestal mounted electronic control cubicle drives the shear group. A pinhole detector and a flying micrometer are ahead of the flying shear and either can operate the classifier gate to reject faulty sheets. Seven 5 hp, 1750/2190 rpm, 230 volt, d-c motors drive the classifier and can be seen in the background to the left of the line.

scaling sprays just ahead of the strip and to again turn them off after the tail end of the strip has passed.

Probably one of the best known and more common uses of photo-electric and electronic control is for loop control regulators. These range in sensitivity from the simple loop regulator, consisting of two or more photo-electric relays operating in the overall control circuit as limit switches, to the highly sensitive photo-thyratron loop regulators, such as that shown in Figures 10 and 11.

Because of the continually increasing speed at which strip processing lines are now being operated, and the increasing size and corresponding increase in weight of coils being processed, the application and design of a photo-thyratron loop regulator, as shown in these pictures, is one of the toughest problems encountered in present day processing lines. In the case of the early loop controls, the strip speeds were low, the physical dimensions of the loop were large, and the coils were small with correspondingly low inertia, with the result that all of these factors combined to make the problem relatively simple. A consideration of each of these factors independently will tend to show the complexity of this problem at the present time. The increased coil size and weight has greatly increased the speed range over which the motor must operate while at the same time greatly increasing the total inertia of the drive. Unfortunately, weakening the motor field to increase the motor speed in an effort to maintain a loop, decreases the motor torque which is obviously undesirable when attempting to change the speed of a high inertia load. The reduced physical size of the loop results in a greatly reduced time interval in which the loop regulator must operate if it is to maintain the loop. The increased line speed further reduces the time interval in which the loop regulator must act, if it is to properly maintain the loop, and at the same time increases the speed range over which the uncoiler motor must operate.

Figure 12 shows another interesting type of electronic control which is commonly known as an edge control. In this type of equipment, a photo-tube and light source are mechanically attached to the winding reel mechanism in such a manner that the edge of the strip intercepts a portion of the light beam. If the strip moves, for any reason, so as to intercept more or less of the light beam, the change in amount of light received by the photo-tube causes it to energize the regulator to move the winding reel in the proper direction to restore the original relationship. Control of this type is becoming more common in order to wind coils having a uniform edge to reduce the damage which otherwise might occur from subsequent handling of these coils for further processing in the mill.

Electronic control is not confined to use as a regulator only, but in some cases, it may be used for detection purposes. Probably, the most common type of electronic device used for detection is the pinhole detector shown in the photograph, Figure 13. Any steel which is to be ultimately used for the making of cans must be free from any holes which would result in a leaking can. However, prior to the use of pinhole detectors, it was extremely difficult to visually inspect the strip and eliminate all of the sheets having pin holes. A modern pin-

Figure 11 — Three phototubes below the inverted lighting fixture maintain proper loop length through the electronic control system contained in the pedestal mounted cubicle at the left. The operator inspects the upper side of the tin plate directly; the under side indirectly through the mirrors.

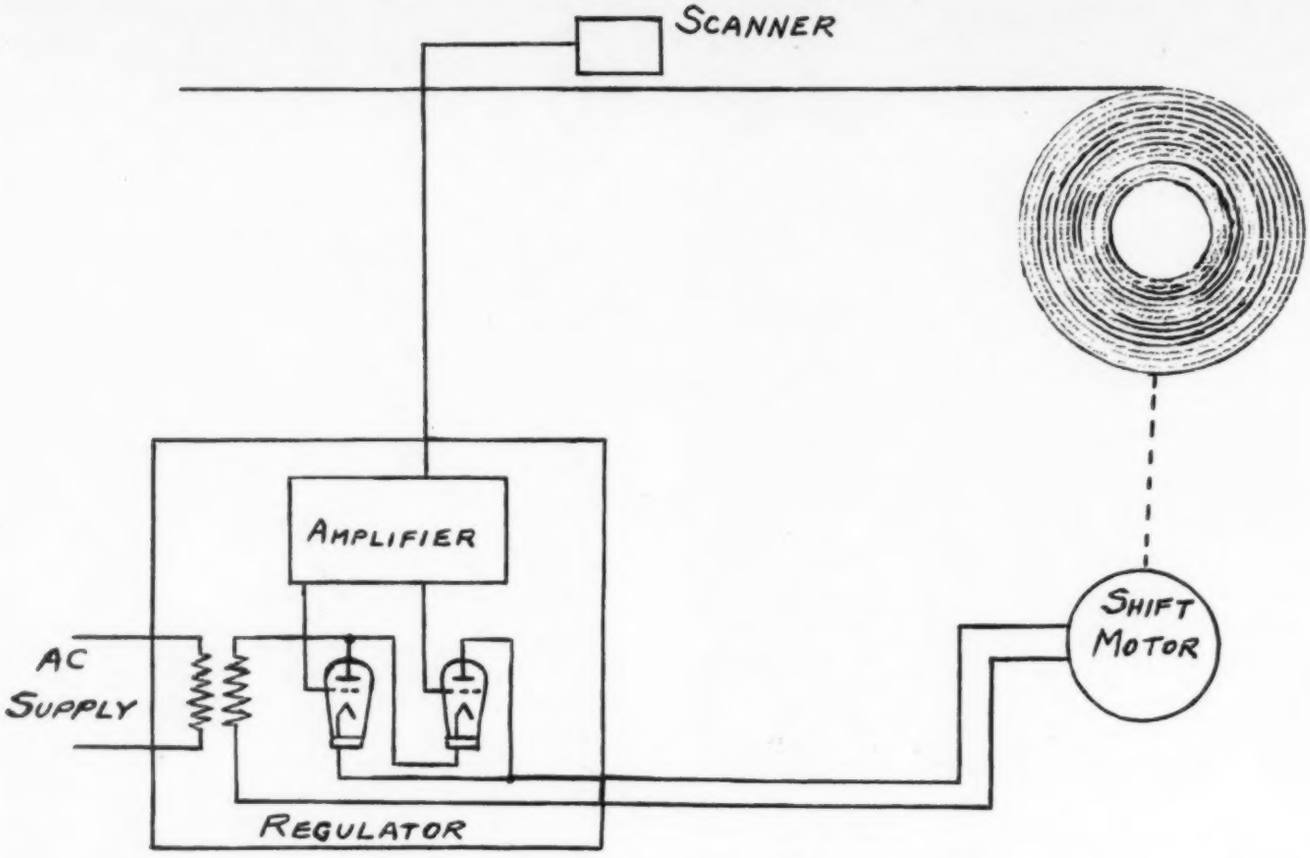


Figure 12 — Electronic devices are used in edge control.

hole detector of this type will inspect continuously moving steel strip at speeds up to 1500 fpm, and will locate or detect holes in the order of $\frac{1}{64}$ in. in diameter.

Another interesting application of electronics for detection purposes is the X-ray thickness gage. In this device, an X-ray tube is mounted on one side of the strip and a detection device such as a Geiger counter or photo-multiplier is mounted on the other side of the strip. The thickness of the moving strip is then gaged by counting the number of X-rays which actually penetrate the strip in a given time. Since the total percentage of X-rays passing through the strip in a given time will be dependent upon the density of the material being gaged, it becomes apparent that when gaging material of a particular kind, and consequently constant density, the percentage of X-rays penetrating the material will be dependent entirely upon the thickness of the material. A gage of this type is free from errors caused by vibration of the strip which is one of the sources of error in a magnetic type thickness gage, in which the rolls must physically contact the strip, resulting in the

Figure 13 — A typical installation of a pinhole detector on a strip shearing line. The light source for the pinhole detector is in the sheet steel enclosure above the strip just in front of the operator.

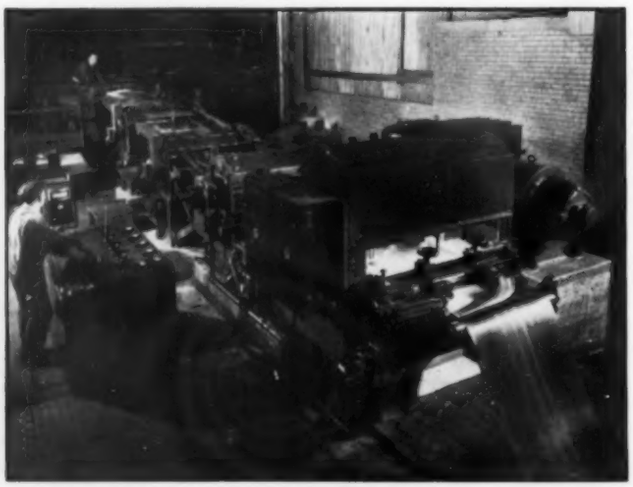
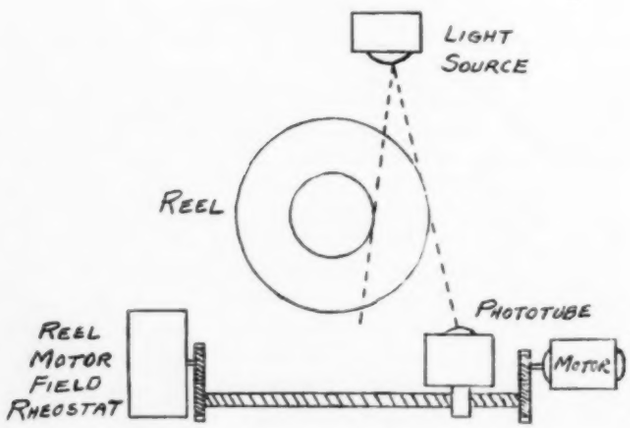


Figure 14 — Schematic diagram of a photo-electric rheostat.



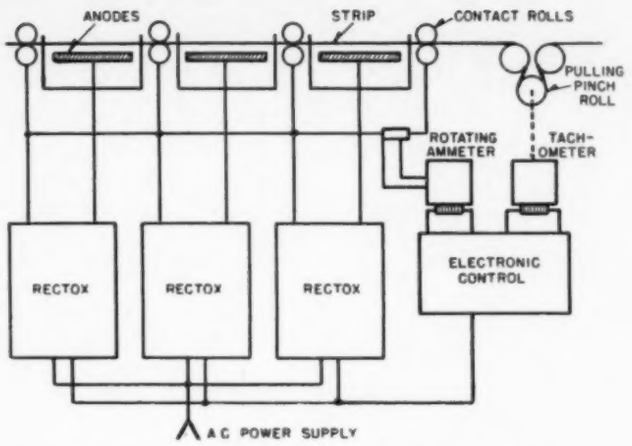


Figure 15 — The plating speed regulator is an electronic control development which was made for continuous electrotinning lines.

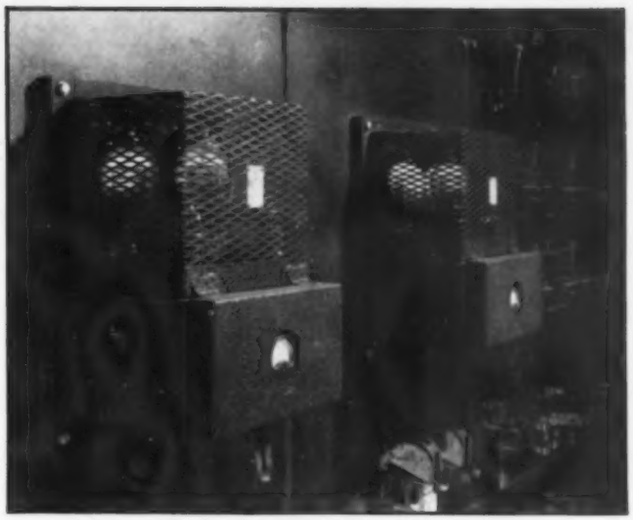


Figure 16 — Uniform thickness of the tin coating applied electrolytically to steel strip is dependent upon maintaining the proper relationship between the speed at which the strip passes through the solution and the amount of the plating current. This delicate balance is maintained by these two electronic controls.

vibration of the strip being transmitted to the gage itself. Furthermore, in gaging material where surface finish is of prime importance, such as tin plate, there is no marking of the strip by a gage of the X-ray type, since it does not make physical contact with the strip in any way.

Figure 14 shows a schematic arrangement of a photo-electric rider roll rheostat. Since the constant current method of tension control does not maintain exact tension throughout the entire buildup of the coil, this device has been developed for applications requiring good tension control. The photo-electric equipment is arranged so as to operate a rheostat which controls the field of the reel motor thus constantly recalibrating the motor field as the coil diameter changes. Tension is then maintained by using a constant current regulator controlling a series booster in the armature circuit of the reel drive. With this arrangement, the tension will be constant since the motor field varies only as a function of the coil diameter and the armature current varies only as a function of tension.

The tin shortage created by the recent war resulted in a new method of producing tin plate. As a result of the shortage, it became necessary to use thinner coatings of tin in order to conserve the greatly diminished supply. This resulted in the development of the electroplating of continuous strip which brought about the developments of two rather interesting electronic regulators.

The first of these, the plating-speed regulator, is shown diagrammatically in Figure 15. As it was impossible to operate any of these lines at constant speed, it became necessary to control the plating current proportional to speed if a uniform coating of tin were to be deposited at all times. This was accomplished by combining the intelligence received from the totalized plating current, supplied by either copper oxide plate rectifiers or plating generators, with intelligence received from a speed indicating generator driven from the master drive of the plating line. This intelligence was fed into an electronic regulator which automatically adjusted the excitation of the plating power supply so as to maintain the desired relationship between the plating current and the strip speed. An installation photograph of this regulator is shown in Figure 16. With this regulator,

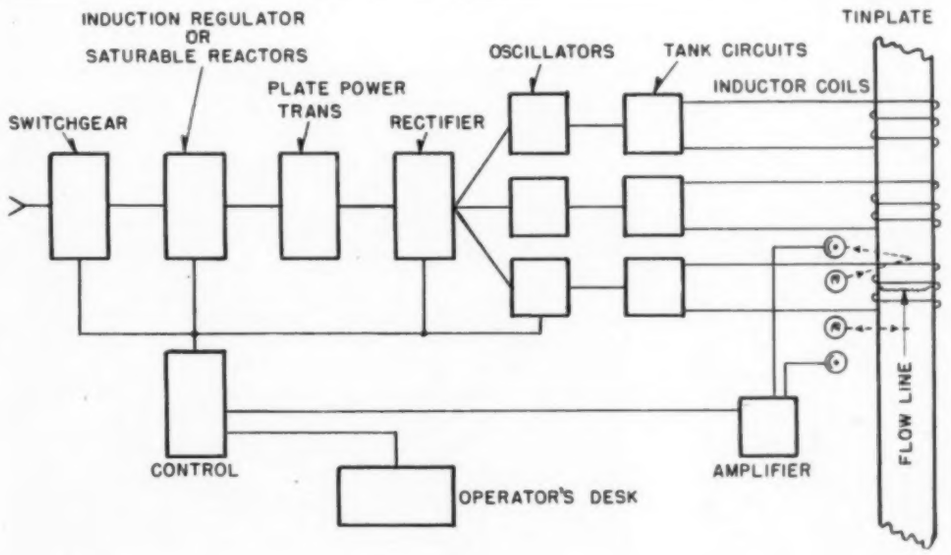


Figure 17 — By means of photo-electric scanner control, reflowing of tin can be controlled regardless of the tinning line speed.

it has been possible to operate these lines over a speed range as great as 50 to 1300 fpm, and maintain the thickness of the tin coating deposited within the commercial tolerances.

With the advent of electrolytic tinplating, it became apparent that the electrolytically deposited tin had a porous matte type of surface which was not satisfactory for use in most tin-plate applications. It, therefore, became necessary to raise this electrolytically deposited tin to its melting point so that it would flow, forming a denser, and less porous coating. Because the final surface of the finished tin plate was important, many of the electrolytic tinning lines used induction heating equipment for this reflowing process, since this method required no physical contact between the heating equipment and the plated strip. Due to the marked difference between the surface of the electrolytically plated strip prior to reflowing of the tin, as compared to the bright mirror like surface following reflowing, we were able to design and develop the photo-electric scanner control, which is shown diagrammatically in Figure 17. In this application, one set of photo-electric equipment scans the strip passing through the inductor coil before it is reflowed or brightened and a second set of photo-electric equipment scans the strip after it has been flowed and a bright surface established. By means of suitable electronic control, this photo-electric intelligence is used to control the power supplied to the induction heating equipment so as to maintain the flow line between the two sets of photo-electric equipment automatically. With this regulator, it has been possible to vary the tinning line speeds over a range of from 50 to 1300 fpm and to properly flow all of the strips passing through the inductor coils.

Another interesting electronic application is the furnace temperature regulating system shown in Figures 18 and 19. This regulator, using intelligence received from a thermocouple or other temperature measuring device, is used to control suitable electronic circuits to vary the excitation of saturable core reactors which in turn control the a-c power supply to the resistance heating elements of the furnace. Formerly, a furnace of this type was controlled by using contactors in the a-c power supply, which were energized and de-energized by the thermocouple, as required, to maintain the furnace temperature. With this contactor type of control a root-mean-square value of power to the furnace was obtained. With this type of control the load factor was poor, because of high current peaks, and the maintenance of large contactors, such as normally required for the application, was usually quite high. With the electronic furnace temperature control, the load factor is constant and the maintenance is negligible since there are no moving parts in a control of this type. Figure 20 shows an installation view of several regulators controlling the several zones of an annealing furnace.

Speed regulation is another field in which electronic control plays a rather important part. One application of this type is shown in Figure 21 in which the speed of

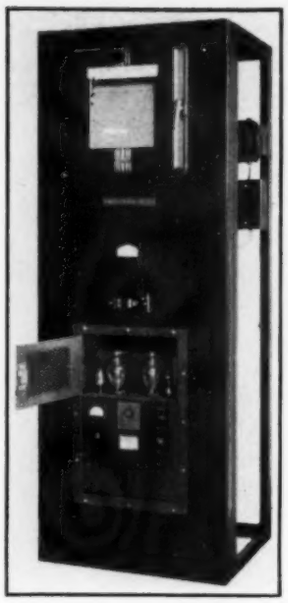


Figure 19 — The electronic furnace regulator is shown with the cover open showing the electronic control tubes. The recording pyrometer is at the top, and the electronic control assembly is at the bottom of the panel.

Figure 18 — Schematic diagram for furnace temperature regulating system.

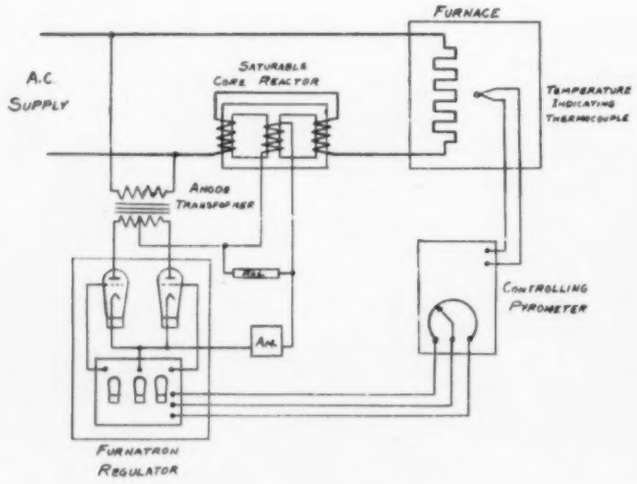
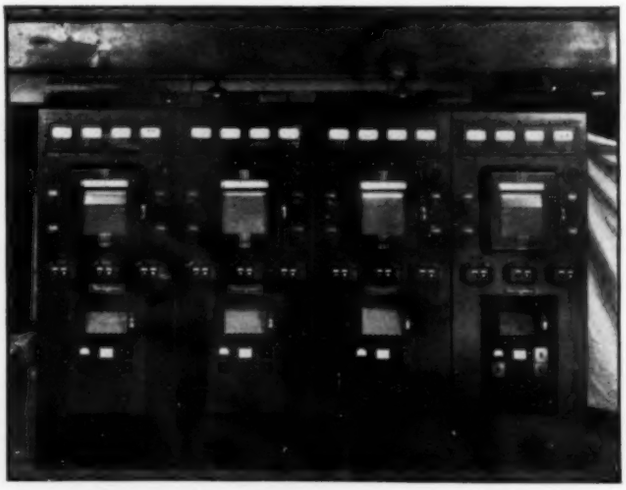


Figure 20 — A group of four furnace regulators which were used to control four separate zones of a continuous furnace. The saturable core reactors which control the input to the furnace are located in a steel structure behind the panels.



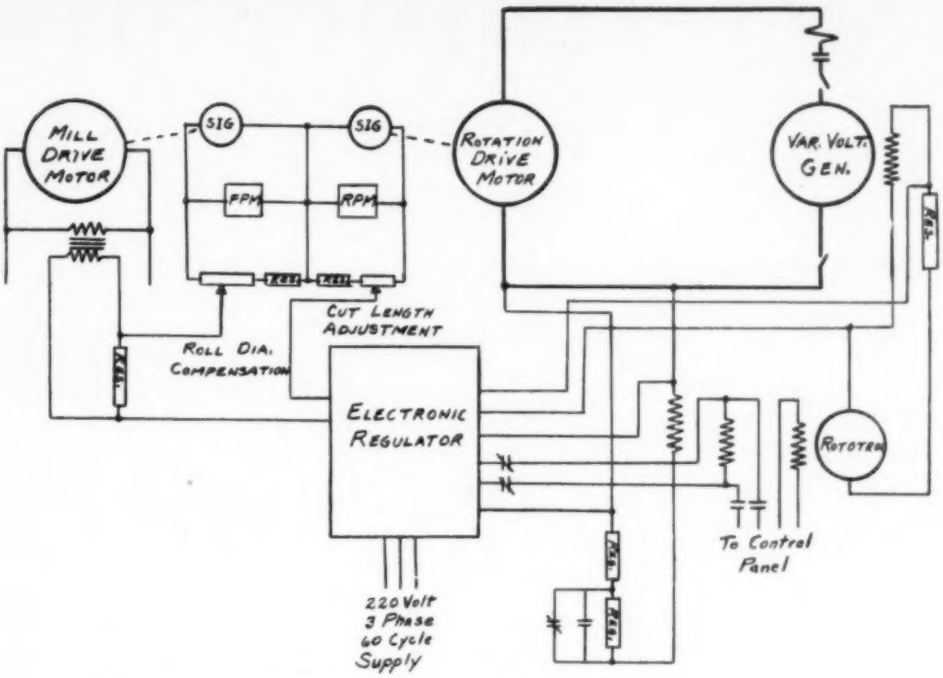


Figure 21 — Electronic control plays an important part in speed regulation such as in this flying hot saw drive.

the driving motor for a flying hot saw is matched with the delivery speed of the mill. The voltage obtained from the speed indicating generator connected to the mill drive is bucked against the voltage obtained from a speed indicating generator connected to the hot saw drive and any difference between these two voltages is amplified and rectified by the electronic regulator and used to control the speed of the saw driving motor so as to make it exactly match speed with the mill.

Another recent application of the electronic speed regulator has been in connection with the driving motors for the individual stands of a rod mill where these regulators are used to reduce the impact speed drop usually encountered when the bar enters the mill. In modern continuous close coupled rod mills this impact speed drop tends to cause stretching or looping between the various stands which adversely affects the quality of the product being produced and increases the operating difficulties. By the use of electronic speed regulators the speed of each stand is maintained nearly constant irrespective of the load, thus greatly minimizing the stretching or looping which would otherwise occur.

Electronic timing control is used where accurate timing is necessary. One of the more common uses of electronic timers is in conjunction with resistance welding control, where the different phases of the welding cycle are timed very accurately by means of suitable electronic timing circuits.

Another application where electronic timers are quite often employed is where it is desirable to delay the starting of equipment until some preset time after a limit switch or other device has been actuated.

On a pickling line which was recently put into operation, ignitron tubes were used instead of the conventional magnetic contactors to energize and de-energize the welding transformer for the flash welder used to weld the ends of the coils together. We believe that the use of ingitrons for this application will very greatly reduce the maintenance as well as considerably speed up the operation of the welder. In addition, the welding cycle is actuated by an electronic timer which properly times the various phases of the welding cycle.

In conclusion, we feel that the applications which have been described are typical and representative of the electronic control currently being used in the steel industry. These applications have only been possible because of a close coordination between the mechanical, magnetic, electrical, and electronic design. It is only through a proper integration of these components that we can hope to obtain the precision and reliability required by these applications. If the proper combination is not made; for example, if a regulator having an accuracy of ½ per cent is attempting to control a machine with 5 per cent back-lash or lost motion, quite obviously the regulator cannot be expected to improve on the inherent mechanical efficiency of the system. Conversely, if a precision machine is combined with a control of relatively low accuracy, the fundamental precision of the machine itself will be destroyed in the resulting combination.

We do not know of any criterion which may be used in deciding when and where the electronic control should be used. There have doubtlessly been some applications of the electronic control where better results could have been obtained through the use of conventional rotating equipment in combination with magnetic or variable voltage control. On the other hand, there are doubtless some applications where great pains and considerable ingenuity have been used to obtain the desired results with conventional apparatus which could have been greatly simplified if electronic control had been used to do all or at least a part of the job.

Consequently, it becomes necessary to study each new application to determine which method or combination will most economically meet the requirements of that particular application. We believe that there will be more and more use made of electronic control in the future.

CONTINUOUS FLOW *Internal*

THE South Philadelphia Works of the Westinghouse Electric Corporation has in operation what may be the first production line in the United States for the internal pickling of low carbon steel pipe by continuous flow of pickling solutions through the pipe.

Developed to prepare absolutely clean pipe assemblies to be used as oil lines for delivering oil under pressure to the bearings of steam turbines, the new pickling method employs a continuous flow of pickling solutions through the inside of the pipe assemblies rather than the nearly static pit soaking method that is normally employed for pickling operations. Moreover this new arrangement permits the use of a moving production line for handling the pipe.

As a result, oil lines for steam turbines are now being turned out in cleaner condition than ever was possible by soaking pit methods, the production time for the operation has been cut to less than one-third of the previous time, and the man-hours of labor are reduced by one-half.

Absolute internal cleanliness of oil lines is essential in turbines, for spindles in the larger turbines (rated at 150,000 kw) may weigh up to 60 tons and must turn on the oil coating of two journal bearings. The oil is delivered through the pipe at 100-150 psi pressure, and the slightest amount of abrasive matter carried into the bearings from the pipe would result in ruined bearings and a ruined turbine.

The new pickling operation is based upon the well-known principle of the superior cutting action of corrosive fluids when they are employed under active rather than static conditions of flow—the fluids in this case being caustic soda, hydrofluoric acid and sulfuric acid pickling solutions. Establishment of the process was made possible by the use of fabricated carbon and of impervious graphite as materials of construction in the critical areas (they are immune to the action of all the pickling solutions employed), and by use of new straight line routing for the process steps.

The operation consists, in brief, of bringing the pipe assemblies (which may consist of five or six pipes from ½ to 10 in. inside diameter, welded together and bent in intricate shapes) in from a railroad car through a storage wing of the building by overhead monorail, and placing them in a drainable position on wheeled traycars in the pickling room. These cars roll sideways on train rails from a drain hearth for hot caustic soda pickling at the entrance side of the pickling room, across a partition of carbon brick to a hot rinse hearth for the caustic soda; across another partition to a drain hearth for the hot hydrofluoric acid treatment, and again over a partition to the hearth for hot rinse of hydrofluoric acid; then to a drain hearth for hot sulfuric acid treatment, and to a platform for hot water rinse of sulfuric acid. The pipe structure then is lifted from the traycar by another monorail which carries it from the pickling line to a second wing of the building where it is given an atomized oil spray, and thence out to a railroad car.

The tray cars are so built that, by lifting the handle at the end of the car, a catch is released and the car is easily rolled to the next position. Lowering the handle drops the catch and locates the car in its next position.

The hearths are 27 ft 0 in. long and average 8 ft 0 in. wide between partitions, with a 4 in. drop from front to rear of each, and an 8 in. drop sideways across the room from the wall at the entrance wing to the wall at the exit wing. The hearth for hydrofluoric acid treatment is double the width of the other hearths to accommodate three cars at once, since the hydrofluoric acid pickling period was originally planned to be three times as long as that of the caustic soda and sulfuric acid periods. A working aisle 5 ft 0 in. wide runs the length of the room at the head of the hearths, and is separated from the hearths by a carbon brick curb.

The pickling hearth floors, rinse hearth floors, side walls, partitions, pedestals and working aisle are all of carbon brick; and at the far (low) end of the pickling and rinse hearths are traps which lead to 800-gallon tanks below the level of the hearths. The tanks are 3 ft 0 in. by 8 ft 0 in. by 7 ft 0 in. deep (the hydrofluoric tank is 16 ft 0 in. long and holds 1500 gallons) and also are built of carbon brick. They contain the pickling solutions (4 per cent caustic soda, 4 per cent hydrofluoric, 4 per cent sulfuric) and the rinse water, and have exit pipes at their bottoms through which the fluids are drawn back through impervious graphite shell-and-tube heat exchangers to pumps, also made of impervious graphite, which lift the fluids to the front end of the pipe assemblies on the tray-cars. Porous carbon steam diffusers are used in place of impervious graphite shell-and-tube exchangers in the caustic soda tank and all rinse tanks.

Connections are made to the pipe assemblies by means of short connecting pipes with flanges at each end. One flange (with a buna rubber gasket) is attached to the pipe assembly, the other flange to the inlet hose from the pump.

In order to provide sufficient back pressure to keep the pipe assemblies full of pickling solution or rinse water up to the highest point in the assembly, and still permit flow of the solution through the pipes, slotted wooden plugs are pounded into each of the remaining

Figure 1 — Below is an external view of the building used for internal pickling of steam turbine oil line assemblies at the South Philadelphia works of Westinghouse Electric Corporation. Pipe assemblies are carried into the pickling room by overhead monorail, as shown below left, and are returned after finish of the operation through the far wing to a railroad car as shown at right.

pipe exits. The fluid can flow slowly through these slots, and enough pressure is maintained by the pump to establish a flow from the plug at the highest exit point.

Five tray-cars are used so as to provide a continuous operation. When the first pipe assembly has been placed on its car, the flange attachment is made to the caustic line as the plugs are inserted. The pump is started, and pickling solution is drawn from the tank at the far end through an impervious graphite pipe to the pump and up into the pipe assembly. It flows out the slots in the wooden plugs, drains across the carbon brick floor to the trap, and back to the tank for a return cycle. After 20 minutes of caustic pickling the hose is disconnected from the adapter and the tray-car is moved to the next position for 5-10 minutes of plain water rinse, during which the second car is loaded and started on its caustic soda cycle. The first car then moves on to the hydrofluoric acid pickling for 45 to 60 minutes, the water rinse for removal of hydrofluoric acid for 5-10 minutes, sulfuric acid pickling for 20 minutes, and water rinse for removal of sulfuric acid for 5-10 minutes. The other four cars are now following through, and when the first assembly is lifted away for its oil spray, the first car is lifted by overhead crane and returned over the others to the head of the line to receive another pipe assembly for caustic pickling.

Following the hot water rinse after the last acid cleaning, all flanges and the adapter are removed from the pipe and the pipe is immediately transferred to the rust preventing operation. This spraying is performed with the least possible delay and while the pipe is still hot to avoid having the interior walls develop a flash coat of rust.

The operation from the start to finish is so rapid that the same number of pipe assemblies formerly handled in one week are now pickled in a day and a half.

Another important factor is the safety of the operation for the workmen. The manufacturer believes this is the safest way ever devised for handling pipe in a pickling process.

Each tank has a wooden lid which is kept down over it at all times except during inspection. There is also a protective guard rail set in carbon brick pedestals before the tanks to act as a further safeguard. Moreover, from the time the wooden plugs are set in the assembly when it is on the caustic hearth until the final rinse has been completed after the sulfuric acid cycle, a workman has no occasion to go near the tank or the drainage end of any of the hearths. He shoves the cars along the track from hearth to hearth and changes connections with the various wash and rinse lines from his position on the working aisle at the near end of the cars. At all times from start to finish the workmen are the length of the hearth (27 feet) away from the tanks. And the low pressure (3-4 pounds) necessary to fill the pipe assembly with fluid obviates any danger of squirting if a connection becomes loose.

Hot air blowers installed over the working aisle before each hearth act to cut down caustic or acid fog by lowering the relative humidity, and drive it toward the far end of the hearths, where fans draw the fumes from each hearth to the outside of the building.

More important than the speed of the job is the quality of the treatment, for any tendency toward dirty pipe or spotty pickling is eliminated. Every vestige of sand and scale is removed from the inside of the pipe and it comes clean right down to the white metal. In fact, cleaning with caustic soda and sulfuric acid alone by this process is superior to the old method when it included hydrofluoric acid.

The continuous flow internal pickling process was placed in routine operation on May 1, 1947.

Included in the equipment list are enough standard size, scored carbon brick to cover 2235 square feet of floor space, plus side walls, partitions, pedestals and tanks; six impervious graphite pumps to move the corrosive fluids and rinse waters; three impervious graphite tube-and-shell heat exchangers of 24 ft 6 in. square feet outside tube area to heat the HF and H_2SO_4 solutions; four porous carbon diffuser elements to heat the caustic soda solution and the three rinses; 195 feet of imprevious graphite pipe; some acid resistant brick; five tray-cars with sealed roller-bearing wheels; fans, blowers, rails, and three 2-ton electric hoists.

The building is constructed with standard I beams and corrugated iron sides and roof. The latter have a protective coating of bituminous pitch on both sides. The usual structural arrangement is reversed, however, for the beams are placed on the outside to save them from corrosion.

Acid resistant paint is applied liberally to the tray-cars, hoists, flanges, and other metal parts inside the building.

Figure 2 — In this photo is shown a partial view of the floor of the pickling room at Westinghouse Electric Corporation. Pipe assemblies are placed upon tray-cars, as shown below, which are moved from location to location on rails set in pedestals of carbon brick. The pickling hearth floors, rinse hearth floors, partitions, pedestals and working aisle are all of carbon brick, as are the pickling fluid tanks and rinse water tanks set below floor level at the far end of the hearths.

1948 ANNUAL CONVENTION AND IRON AND STEEL EXPOSITION

CLEVELAND PUBLIC AUDITORIUM

CLEVELAND, OHIO

SEPTEMBER 28, 29, 30, AND OCTOBER 1

Tentative Program

Tuesday, September 28

IRON AND STEEL EXPOSITION — 10:00 a.m.-10:00 p.m. — Arena and Exhibition Hall

9:00 a.m. — REGISTRATION — Main Lobby

9:00 a.m. — LADIES' REGISTRATION AND HEADQUARTERS — Parlor L-M, Hotel Statler

9:15 a.m. — BUSINESS MEETING — Ball Room

Conducted by President A. J. Fisher

9:30 a.m. — ELECTRICAL SESSION — Ball Room

Chairmen: I. N. TULL
Republic Steel Corporation
J. D. O'ROARK
Weirton Steel Company

"Some Results of Mercury Arc Rectifier Operations in Carnegie-Illinois Steel Corporation Plants," by Frank W. Cramer, Carnegie-Illinois Steel Corporation

"Electric Cables for the Steel Industry," by E. W. Davis, Simplex Wire and Cable Company

"Air Conditioning of Crane Cabs," by R. D. Darrah, Dravo Corporation

12:00 M. — LADIES' LUNCHEON

(Meet at Ladies' Headquarters)

ALL EVENTS EXCEPT SOCIAL FUNCTIONS WILL BE HELD AT CLEVELAND PUBLIC AUDITORIUM

2:00 p.m. — OPERATING PRACTICE SESSION — Club Room B

Chairmen: J. L. TATMAN
Wheeling Steel Corporation
WILLIAM H. COLLISON
Great Lakes Steel Corporation

"Hot Blast Stoves for Modern Blast Furnaces," by R. L. Clark, John Mohr & Sons

"Blast Furnace Practice at Fontana," by C. H. Lenhart, Kaiser Company, Inc.

"Special Cars in Steel Plants," by E. W. Schellentrager, The Atlas Car & Manufacturing Company

2:00 p.m. — STANDARDIZATION SESSION — Ball Room

Chairmen: F. W. CRAMER
Carnegie-Illinois Steel Corporation
LEONARD LARSON
Republic Steel Corporation

"Report of Standardization Committee — 1948," by Frank W. Cramer, Chairman AISE Standardization Committee

"Analytical and Experimental Studies of Ladle Hooks," by Carl W. Muhlenbruch, Northwestern Technological Institute

"Stresses in Hot-Metal Ladles," by K. E. Knudsen, W. H. Munse and B. G. Johnston, Fritz Engineering Laboratory, Lehigh University

10:00 p.m. — EXHIBITORS' DANCE — Euclid Ball Room, Hotel Statler

Wednesday, September 29

IRON AND STEEL EXPOSITION — 10:00 a.m.-10:00 p.m.

9:00 a.m. — COMBUSTION SESSION — Ball Room

Chairmen: B. B. BARGMAN
Carnegie-Illinois Steel Corporation
E. C. HITE
Timken Roller Bearing Company

"Steel Temperature Measurement and Control of Reheating Furnaces," by Fred S. Bloom, Bloom Engineering Company, Inc.

"Maintenance of Hearths in Heating Furnaces and Soaking Pits," by Charles N. Jewart, Bethlehem Steel Company

"Effect of Oxygen on Refractories in the Basic Open Hearth," by R. S. Moore, Harbison-Walker Refractories Company

11:30 a.m. — LADIES' LUNCHEON

(Meet at Ladies' Headquarters)

Wednesday (Continued)

2:00 p.m. — MECHANICAL SESSION — Club Room B

Chairmen: F. S. ECKHARDT
Bethlehem Steel Company
P. L. WALTER
Republic Steel Corporation

"Mechanical Insert Repairs in the Steel Industry," by R. L. Rectenwald, Metalock Corporation of Pennsylvania
"Water Works Maintenance," by George H. Dann, Philadelphia Suburban Water Company
"What the Machine Tool Industry Wants from the Steel Industry," by Tell Berna, National Machine Tool Builders' Association

2:00 p.m. — ELECTRICAL SESSION — Ball Room

Chairmen: V. E. SCHLOSSBERG
Inland Steel Company
D. C. NELSON
Jones and Laughlin Steel Corporation

"Electrical Equipment for Rolling Cold Strip at 70 Mph," by William E. Miller, Steel Mill Division, General Electric Company
"Review of D-c Drives on Runout Tables and Coilers," by I. N. Tull, Republic Steel Corporation
"Improved Flying Shear Drive," by J. Raymond Erbe, Industry Engineering Department, Westinghouse Electric Corporation

6:00 p.m. — OLD TIMERS' DINNER — Euclid Ball Room, Hotel Statler

Thursday, September 30

IRON AND STEEL EXPOSITION — 10:00 a.m.-5:30 p.m.

9:00 a.m. — ELECTRICAL SESSION — Ball Room

Chairmen: R. W. GRAHAM
Bethlehem Steel Company
A. D. HOWRY
Alan Wood Steel Company

"Magnetorque A-c Crane Control," by F. W. Wendelburg, and F. M. Blum, Harnischfeger Corporation
"A Network System for Dynamic Lowering Hoist Control," by D. L. Pettit, Square D Company
"Designing the Proper Equipment for Extracting Ingots from their Molds," by H. W. Ball, The Morgan Engineering Company

9:00 a.m. — COMBUSTION SESSION — Club Room B

Chairmen: H. S. HALL
Lukens Steel Company
C. E. DUFFY
Bethlehem Steel Company

"Training Instrument Mechanics at Sparrows Point," by F. R. Pullen, Bethlehem Steel Company
"Fuel Oil in the Steel Industry," by A. J. Fisher, Bethlehem Steel Company
"Liquefied Petroleum Gases for the Steel Industry," by Francis E. Drake, Pacific Gas Corporation

2:00 p.m. — LUBRICATION SESSION — Club Room B

Chairmen: D. N. EVANS
Inland Steel Company
R. A. BARTA
Republic Steel Corporation

"High Temperature Lubricants and Their Evaluation," by G. L. Sumner, Westinghouse Electric Corporation
"Centrifugal Clarification of Oil in Steel Plants," by Charles M. Ambler, The Sharples Corporation
"Bearing Seals," by R. A. Kraus, Republic Steel Corporation

2:00 p.m. — ROLLING MILL SESSION — Ball Room

Chairmen: C. W. BARRETT
Republic Steel Corporation
J. N. IMEL
Jones and Laughlin Steel Corporation

"Analysis of Cold Mill Design," by Frank P. Dahlstrom, Arms-Franklin Corporation
"Beam and Channel Roll Design," by Ross E. Beynon, Carnegie-Illinois Steel Corporation
"The Fundamental of Hot Rolling," by George S. Mican, Carnegie-Illinois Steel Corporation

7:30 p.m. — FORMAL DINNER-DANCE, Grand Ball Room, Hotel Statler

Speaker: J. E. Goble, President, National Tube Company

Friday, October 1

IRON AND STEEL EXPOSITION — 10:00 a.m.-4:00 p.m.

9:00 a.m. — MATERIAL HANDLING SESSION — Ball Room

Chairmen: H. W. NEBLETT
Inland Steel Company
A. G. ERICSON
Carnegie-Illinois Steel Corporation

"Coal Preparation for Steel Manufacturers," by N. L. Davis, Nelson L. Davis Company
Problems in Handling Heavy Coils — Symposium
Cranes — R. G. Birkin, Cleveland Crane & Engineering Company
Trucks — C. F. Kells, The Electric Industrial Truck Association
Conveyors — J. E. McBride, Palmer-Bee Company

2:00 p.m. — LUBRICATION SESSION — Club Room B

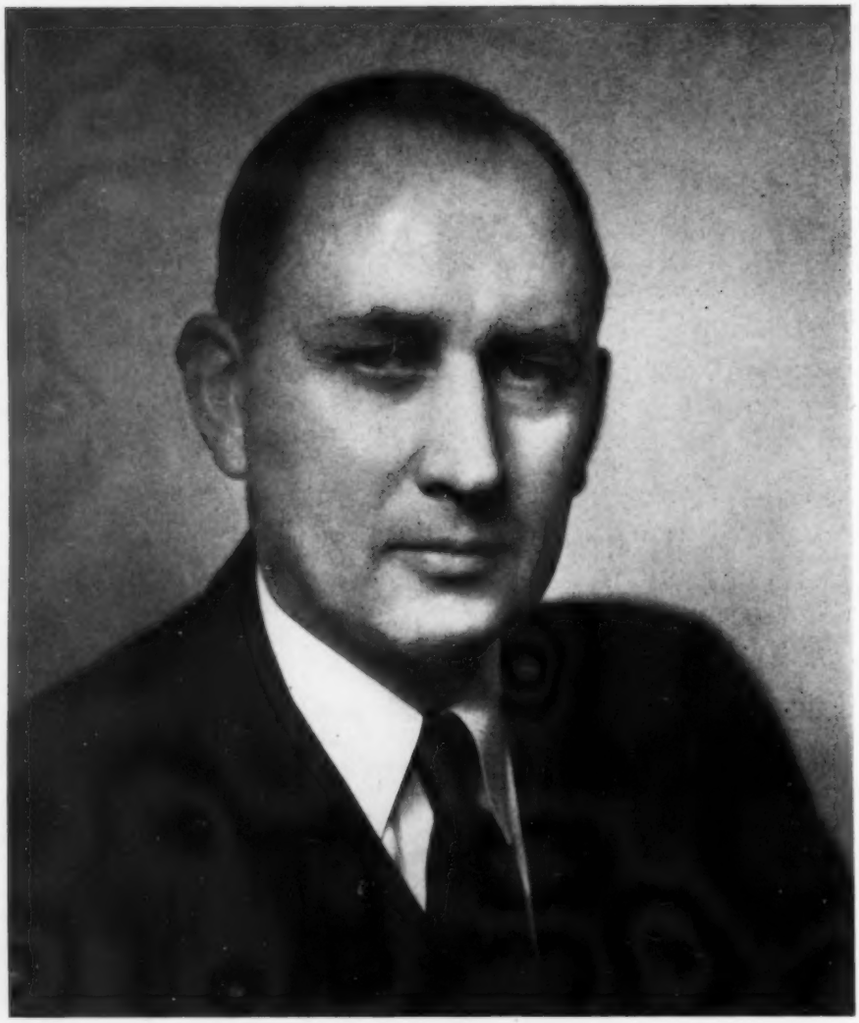
Chairmen: C. E. PRITCHARD
Republic Steel Corporation
A. E. CICHELLI
Bethlehem Steel Company

"Developments in Sleeve Bearings," by A. B. Willi, Jr., Federal Mogul Corporation
"Preventive Maintenance of Electric Oils," by C. J. Egger, Bowser, Inc.
"The Use of Rust Preventives in the Maintenance of Steel Structures," by Joseph G. Surchek, Dearborn Chemical Company

2:00 p.m. — OPERATING PRACTICE SESSION — Ball Room

Chairmen: C. L. McGRANAHAN
Jones and Laughlin Steel Corporation
J. S. STANIER
Youngstown Sheet and Tube Company

"Developments in Butt Weld Tube Mills," by W. Rodder, Aetna-Standard Engineering Company
"Strip Welding," by F. R. Thompson and F. J. Waldschutz, Mesta Machine Company
"Mandrel Type Hot Strip Coiler," by G. E. Farrington, E. W. Bliss Company

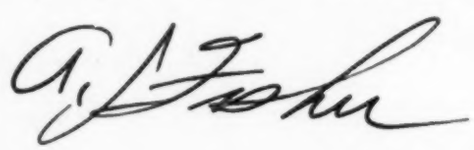


An Invitation to All Steel Industry Personnel

The 1948 Annual Convention and Iron and Steel Exposition of the Association of Iron and Steel Engineers again presents to the men of the industry a fine opportunity to view and discuss modern developments and improvements in engineering and operating practices.

Bigger in scope than ever before in the Association's history, these activities will offer an overall perspective of post-war developments, at a time when productive efficiency is again of major significance.

On behalf of the exhibitors, and of the officers and staff of the Association, I extend to all personnel of the iron and steel and allied industries a cordial invitation to attend the exposition and technical sessions. We know that participation in these activities will prove profitable.



President, AISE

TECHNICAL PROGRAM OF THE

American Iron and Steel Institute

. . . . in reviewing problems of iron and steel production, leading operators of the steel industry, at the fifty-sixth general meeting of the American Iron and Steel Institute held in New York City on May 26th, presented a number of very interesting papers . . . . special panels were held on Coal and Coke, Oxygen in Steelmaking, Sources of Iron, Refractories, Specialty Steels, and Casting and Finishing . . . . because of their value to the industry, some of the papers are abstracted here . . . .

MODERN MECHANIZED MINING AND COAL PREPARATION FOR METALLURGICAL COAL

By JOHN GRIFFEN, McNally Pittsburg Manufacturing Corporation, Pittsburgh, Pennsylvania

▲ MODERN mechanized mining is concerned with the mechanical loading of run-of-mine coal into the mine car or other means of transportation. The other steps in the production of bituminous coal, such as cutting and transportation, have been done by machines for a number of years, and the industry is familiar with the characteristics of such run-of-mine coal. The wide adoption of machines to load the coal at the face is more recent. The statistics covering the mechanical loading of bituminous coal underground show only 0.3 per cent so loaded in 1923, and it was not until 1938 that the figure exceeded 25 per cent, while by 1946 the amount had reached 58 per cent. Figure 1 shows the accelerated rate of growth, largely imposed by the impact of World War II.

Users of metallurgical coal are interested in mechanical loading equipment because it has tended to affect adversely the quality of the mine output. Generally, the hand-loading of coal enables the use of selective mining methods adapted to the production of a quality product.

During the past thirty years, coal loading devices of various types have been developed, but, as noted, the mobile loading machine seems to be out-performing all over types in the great majority of the bituminous mines of this country. Table I is illuminating on this point:

TABLE I

Units of Mechanical Loading Equipment in Use in Underground Bituminous Coal and Lignite Mines in the United States, 1941-46

Type of equipment	1941	1946	Changes 1946 from 1941, per cent
Mobile loaders	1,985	3,200	+61.2
Scrapers	109	75	—31.2
Pit-car loaders	607	93	—84.7
Conveyors equipped with duckbills or other self-loading heads	788	1,521	+93.0
Hand-loaded conveyors	2,807	3,470	+23.6
Total, all types	6,296	8,359	+32.8

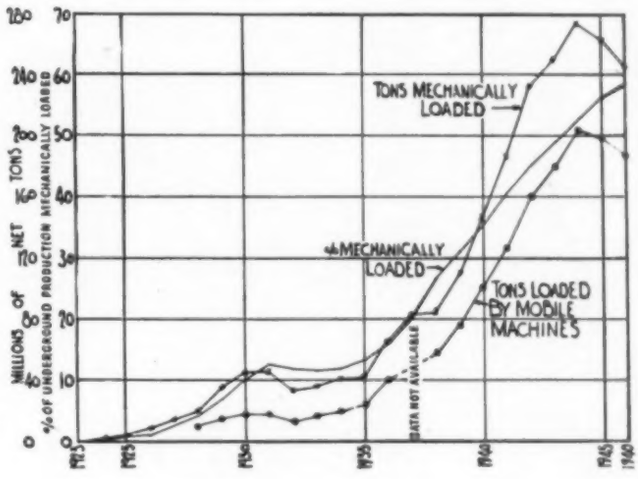


Figure 1 — Growth of mechanical loading at underground bituminous mines in United States, 1923-46.

Generally, it will be agreed that the application of loading machines seriously interferes with the quality controls which were practiced under handloading methods.

The Pittsburgh Seam in western Pennsylvania and northern West Virginia contributes a larger proportion of the coal coked in the United States than any other seam. The figures for 1946 indicate that about 37 per cent of about 84,000,000 tons coked came from the Pittsburgh Seam. It is felt that a study of the changes in quality of raw run-of-mine coal, shown by present experience with mobile loading machines in the various districts of the Pittsburgh Seam, and of experience with coal preparation plants cleaning such output will throw some light on the possibilities for producing satisfactory coking coals, not only from this seam but from other

seams at costs much lower than would be possible with hand-loading methods.

However, much disagreement there may be as to the exact qualities required of a satisfactory coking coal, there seems to be general agreement that uniformity in chemical analysis is essential.

As a criterion of quality in Pittsburgh Seam coking coal, that from the Connellsville district produced by hand-loaded mining methods has been pretty generally

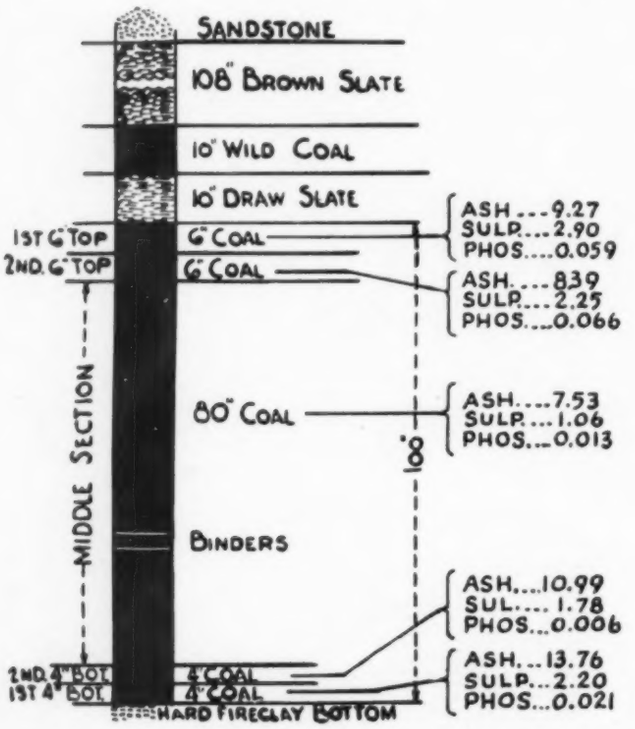


Figure 2 — Typical columnar section and analysis of Pittsburgh coal seam, Connellsville District.

accepted. Figure 2 shows a typical columnar section in this district, with analyses of the various benches of the seam. Attention is called to the high ash and sulphur analyses of the coal at the bottom and at the top of the seam, while the phosphorus is excessive in both six inch bands at the top and in the bottom four inch band. Figure 3 shows a typical mining face, and indicates the selective mining method used to insure the production of clean coal. The seam is cut near the bottom, leaving four to six in. of the poorer quality bottom coal un-

Figure 3 — Typical mining face, selective mining with hand-loading, Connellsville District, Pittsburgh Seam.

mined. The face is then shot so as to leave eight in. or more of the poorer quality top coal as a roof. Until recently, the cutting machine had a cutter bar only about six ft long, which made a cut somewhat less than six ft in depth, and the explosive charges did not need to be particularly heavy to produce a good fall. Thus, the run-of-mine produced was reasonably coarse and there was less chance that the top coal or the draw slate would be broken down. The miner, while loading the broken coal into the mine car, discarded any large pieces of refuse.

With mobile machine loading, the cut is made about nine ft deep, instead of the usual six ft with hand-loading, to increase the tonnage of coal to be loaded per place. This deeper cut necessitates heavier shooting, which increases the amount of fine coal produced. More fine coal may reduce bulk density. If the coal is to be washed, more fine coal may add to cost of washing and raise the moisture content of the washed coal. A mobile loading machine cannot select the good coal from the bone and refuse. Despite the care of the machine crew, there is an inevitable increase in refuse and impurities in machine-loaded coal.

A coal preparation plant, designed to make a uniformly low-ash and low-sulphur metallurgical coal from the dirtier and more variable raw coal produced by modern mechanized mining, either "Selectivity" or "Full Seam" mined, involves somewhat higher investment and operating costs per ton of output. We, as yet, have insufficient experience to establish these costs and the qualities of the products with exactness. Estimates have been made of combined mining and preparation costs of the Pittsburgh Seam which, if approximately fulfilled, will show a very definite saving over coal produced by hand-loading "Selective Mining" methods. One such estimate is as follows:

Type of mining and preparation	Relative cost per ton clean coal
Selective mining, hand-loading	100
Selective mining, mobile machine loading and mechanical preparation	85
Full seam mining, mobile machine loading and mechanical preparation	75

When we realize that today's costs for Pittsburgh Seam run-of-mine coal produced by hand-loading exceed $4.00 per ton, the above figure shows a considerable margin, something like 60 cents to $1.00 per ton, to cushion any errors in estimating costs.

In the districts of the Pittsburgh Seam inWestern Pennsylvania producing coking coals, the use of modern coal-washing and blending facilities offers assurance of correcting the adverse effects of mechanical loading on coal quality at a substantial saving in cost per ton of coal delivered to the ovens and of coking coal cost per ton of pig iron.

Coal preparation technique should be applied to overcome the adverse effects of mechanical loading used in mining coking coals from all seams along the following principles:

A—Where the impurities are mainly associated with

heavy-gravity refuse, conventional coal-washing equipment is most economical.

B—Where a significant proportion of the impurities or unwanted qualities are associated with intermediate gravity material of usable calorific value, the newer, somewhat more expensive processes, capable of sharp separations at low gravities, should be additionally employed to produce a middling, or second-grade coal, for boiler coal.

C—Where the unwanted impurities or qualities are associated with the purer coal substance in variable amounts, such as sulphur, phosphorus or expanding properties, coal washing should be employed to control the average values and blending should be added to eliminate or reduce the variability of the injurious impurities or qualities.

PROPER SIZING, SCREENING AND PREPARATION OF BLAST FURNACE COKE

By D. P. CROMWELL, Superintendent, Campbell Blast Furnaces, Youngstown Sheet and Tube Company, Youngstown, Ohio, and C. A. COVINGTON, Superintendent, Campbell Coke Works, Youngstown Sheet and Tube Company, Youngstown, Ohio

▲ THE history of the uncrushed and unscreened coke used by the Youngstown Sheet & Tube Company prior to 1929 reveals a story of low production, high coke rates, and fluctuating analyses of pig iron.

Coincidental with larger furnaces came coal washing, sintering of ores, better average analyses of all raw materials. These changes all have made for better and higher operating rates that can be attained only by thoroughly sizing and cleaning the coke. It has been found in practice, and substantiated by tumbler and screen tests that primarily, coke must be made strong enough to stand crushing and screening.

At the Campbell coke plant, the coke from ovens is dumped on the wharf which delivers it to a 42-inch belt 1440 feet long travelling at a speed of 296 fpm. This belt delivers the oven run coke to the oversize rotary scalpers set at 3 inches disk to disk. Coke under 3 inches passes through the scalpers to the rotary furnace grizzlies and the oversized coke goes to the crusher which is set at 3¼ inches. Thirty per cent of all coke is crushed.

The coke which goes over the rotary scalpers and through the crusher combines with the coke through the rotary scalpers, and either passes over or through the rotary furnace grizzlies which are set at 2 in. disk to disk.

The furnace coke which passes over the furnace grizzly goes to a 36-inch belt 83 feet long travelling at a rate of 314 fpm which in turn carries it to a 36-inch cross belt 66 feet long travelling at the same speed. This belt delivers the furnace size coke to another cross belt 42 inches wide and 138 feet long which travels at a speed of 260 fpm. This belt delivers it to the transfer car and trailer having a 50-ton capacity each. The transfer car and trailer are electrically driven and carry the coke to the blast furnace bins over a trestle which spans the Mahoning River. Fifty-nine per cent of all coke is furnace size, 2 in. x 3½ in.

The coke passing through the rotary furnace grizzlies consists of stove, nut and breeze, and goes to No. 1 or No. 2 double deck classifier screens. These screens are equipped with a top deck screen of 2 in. by 2.5 in. openings, and a bottom deck of 1.75 in. by 2 in. openings.

The stove coke passing over these screens delivers on a 36 in. belt 73 feet long with a speed of 314 fpm, and delivers to a 36 in. reversible cross belt 144 feet long with a speed of 314 fpm. At present this belt delivers the stove coke to the furnace coke belt where it combines with the furnace coke loading into the transfer car and trailer. The belt when reversed delivers the stove coke to railroad cars for emergency loading, stocking, or for sales. Twenty and thirty-five hundredths per cent is stove size spread uniformly throughout furnace coke—1¾ x 2½ in.

The coke which goes through the bottom screens of No. 1 and No. 2 Gyrex passes to No. 3 Gyrex screen consisting of a top screen 1.25 in. by 1.50 in. opening and bottom deck of 0.75 in. x 1.25 in. opening. The nut coke passes over the screens to a 24-inch belt 72 feet long which delivers it to railroad cars that are shipped to the blast furnace by rail. Twelve and forty hundredths per cent of all coke is nut size and is charged separately—¾ in. x 1½ in.

The breeze coke passing through the lower deck goes to No. 4 Gyrex screen equipped with a top deck of 0.5 in. x 1 in. opening and a bottom deck of 0.25 x 3.5 in. opening. The coarse breeze passing over these screens goes to a 24-inch belt 52 feet long and runs at a speed of 142 fpm. This belt takes the coke to railroad cars that are shipped to the boilerhouse for fuel. Four and twenty-seven hundredths per cent of all coke is made on this screen—¾ in. x ¼ in.

The fine breeze (¼ in. and smaller) passes through the lower screen directly to railroad cars, and is shipped to the sintering plant; 3.98 per cent of all coke is taken from this screen and sent to the sintering plant for ignition fuel.

Each furnace is also equipped with a vibratory screen with a ¾ in. x 1¼ in. bottom deck. Two per cent breeze is collected at this point immediately before going into the skips.

Late in 1928, screening and crushing was started. Coke improved both chemically and physically. It is of note that coal ash was up and sulphur remained constant. Crushing and screening resulted in a drop of almost 1 per cent in ash and 0.03 per cent in sulphur in the coke.

Furnace operation improved up to 2.617 tons per sq. ft. of hearth area, an overall increase of 11 per cent. Dust dropped 21 per cent. Pressure conditions were practically eliminated. Iron quality improved considerably especially on bessemer where better yields were experienced. The stability factor increased to 54.12 per cent from a previous average of 46.91 per cent.

Table I brings the Campbell operating up to date. In addition to washing of the coal, mechanical mining was introduced. Larger furnaces were built in 1941 and 1942, so that the effect of higher wind volumes was felt to the extent of 1300 tons per day on one of the furnaces. A sintering plant was constructed also in 1942, so that ore beneficiation was a factor in higher tons per

TABLE I

Campbell Furnace Performance as Operating with Present Equipment

COAL

1943-'47	VCM	Fixed carbon	Ash	Sulphur	
Average	30.30	61.89	7.88	1.28	

COKE

					Stability	2 in. screen test
Average	1.08	88.30	10.67	1.07	53.28	52.24

IRON

	N.T. per day	N.T. per sq ft hearth	CFM	Coke per ton	Dust per ton
Average	972	2.517	61,182	1751	161

sq. ft. of hearth area. The grand average of 2.517 tons could not have been maintained without good coke every day and every hour. The stability factor of 53.28 per cent did not vary to any great extent during the five years.

It is the opinion of most blast furnace operators that a furnace operates well only because of a uniformly distributed gas flow around the periphery of the furnace. The usual percentage of coke charged into a furnace by volume is 66 per cent, so that the size of fuel governs to the greatest extent the uniform velocity of gases in the stack. If this size remains constant (partly because of its inherent stability), the operator has one hitching post to tie his horse to. The size of other variables such as limestone, sinter, ore and open hearth slag may be controlled by the same means as in a good coke screening station. Therefore it becomes a much simpler problem when the operator has two-thirds of his burden always the same.

Table II shows some operating statistics of the Campbell furnaces, which show uniform practice resulting from uniform coke stability, in spite of higher ash and sulphur coals, and leaner ores.

TABLE II

Campbell Furnaces Operating Statistics

Year	N.T. of iron per day	N.T. per sq ft hearth	Carbon per ton	Per cent sinter	Dust per ton	Stability
1939	3097	2.43	1448	0.8	92	53.47
1940	3113	2.46	1455	0.0	84	54.58
1941	3467	2.48	1444	0.8	125	53.13
1942	3623	2.52	1444	4.9	136	53.27
1943	3983	2.57	1411	33.0	153	52.17
1944	4029	2.53	1411	34.5	161	54.23
1945	3859	2.44	1425	29.2	174	53.52
1946	3641	2.36	1446	25.9	166	53.88
1947	3795	2.45	1463	21.4	151	52.61

EFFECT OF COKE QUALITY ON BLAST FURNACE IRON TONNAGE

By E. J. GARDNER, Superintendent, Blast Furnaces and Coke Plant, Inland Steel Company, East Chicago, Indiana

▲ IN the past thirty years, the methods used for judging the suitability of by-product coke for blast furnace operation have undergone considerable development. In the early days metallurgical coke was judged by its appearance. With the improvement in the technical standards, it soon became necessary to develop standard tests which were not affected by the human equation. The first of the more practical methods of evaluating coke was the making of screen tests on the coke delivered to the furnaces. The variation in the percentages of the various sizes of coke, which accompanied changes in the coal mixture, coking time and flue temperature at the coke plant, furnished a more scientific method of correlating blast furnace operation and coke quality. The next step was the adoption of physical tests to measure the hardness and strength of the coke; the shatter test giving a measure of the impact hardness and tendency to fracture, and the tumbler test measuring the resistance to abrasion.

While the existing coke physical tests are suitable for detecting changes in the percentage of low volatile coal used in the mixture, changes in the type or rank of coal used, also the effect of variations in the coking time on the physical properties, furnace coke must still be rated according to its performance in the blast furnace, taking into consideration other variables that may occur in blast furnace operations other than those found in coke quality.

From our research investigations on means of improving the quality of the coke, we have learned that we must know more about coal and its expansion and carbonization properties. The quality of blast furnace coke originates at the mine and we must select high grade coking coals in order to produce top quality blast furnace coke.

In order to evaluate the coking characteristics of the low and high volatile coals that we use regularly, and to aid us in the selection of safe expanding and satisfactory coking coals to supplement our supply, we have made over 700 carbonization tests in our Koppers movable-wall expansion test oven. Our expansion tests show that for our practice, where we crush our coal so that 80 per cent passes through a ⅛ in. square mesh screen, using a blend of 35 per cent Pocahontas No. 3 Seam and 65 per cent Elkhorn coals—3.50 psi is the maximum expansion pressure of the blend which we can charge safely in our ovens. In addition, the physical tests of the cokes made in the movable-wall test oven are indicative

TABLE I

Significant Data on "B" Furnace Test Runs

Blend	Exp. press. of blend, psi	% coke ash	Avg. coke size	% +2" coke	Shatter %+2"	Tumbler test %+1"	Tumbler test %+¼"	Porosity %	Test time days	Iron prod. net tons per day	Coke used lb/ton	Slag vol. lb/ton	Wind cfm	Burden lb/chge
1. 35% Jenkin-Jones 65% Wheelwright	2.00	6.7	2.08"	47.9	45.4	45.4	68.5	50.4	37	1197	1653	906	71,800	36,400
2. 35% Pocohontas #3 65% Wheelwright	3.60	7.1	2.19"	53.0	51.1	48.6	68.7	51.4	23	1254	1644	906	71,800	37,500
3. 25% Eccles (Beckley) 75% Wheelwright	3.40	7.0	2.18"	55.0	53.0	47.5	67.2	52.3	23	1260	1675	913	71,900	37,100
4. 35% Pocohontas #3 25% Illinois 40% Wheelwright	2.20	8.4	2.22"	55.7	55.0	48.8	66.1	52.9	23	1206	1771	962	71,600	35,600
5. 25% Misc. low volatile 75% Misc. high volatile	1.60	10.7	2.34"	64.7	61.2	40.9	61.0	53.1	37	1184	1720	1040	71,900	35,100

of what may be expected from the same coal mixture when coked in the plant ovens.

In the last few years, we, at Inland Steel Company, as well as other plants in the industry, were faced with the problem of finding a suitable substitute for our rapidly depleting supply of No. 3 Seam Pocahontas coal. We had been purchasing No. 3 Seam Pocahontas for blending with Elkhorn No. 3 Seam coal from the Inland-owned mine at Wheelwright, Kentucky, to make metallurgical coke. The solution to this problem developed into a plant scale research investigation where selected coal blends were carbonized under identical oven operating procedures. The resulting furnace cokes were used in succeeding tests on one blast furnace, where operations were maintained as uniformly as possible so that iron production would be indicative of coke quality. The complete details of these extensive tests appear in the Inland publication, "Investigation of Beckley Seam Coal Blended with Wheelwright Coal for Use in the Production of Metallurgical Coke."

The furnace tests showed that No. 2 and No. 3 blends produced satisfactory cokes, comparable in physical properties and in furnace performance. In other words, we have found in our test work, to date, that coke approximating the following physical properties afforded us our best blast furnace operation

Per cent ash in coke.....7.0
Average size of coke.....2.18-2.19 in.
+ 2 in. Coke.....53-55 per cent
Shatter test + 2 in.....51-53 per cent
Tumbler stability .....47-49 per cent
Tumbler hardness.....67-69 per cent
Porosity .....51-53 per cent

Substitution of Jenkin-Jones for our No. 3 Pocahontas produced smaller coke with lower shatter and stability indices than was obtained from our Inland blend. The iron production was also lower.

When 25 per cent Illinois coal was substituted for some of our No. 3 Elkhorn Seam Wheelwright coal, the coke properties were again altered. The size, shatter index and porosity were increased. The tumbler stability remained the same, but the tumbler hardness was definitely lower. The coke was dark and rough in appearance. Iron production was lower than from the 35 per cent No. 3 Pocahontas-65 per cent Wheelwright blend. Coke consumption was greater due to the higher ash content of the Illinois coal.

When the coal blend consists of miscellaneous low and high volatile coals with extreme variations in expansion characteristics and a higher ash content, as in the mixture used at our Plant No. 3, we produce coke that is larger in size and has lower tumbler stability and hardness values. The use of this type of coke lowers the efficiency of the blast furnace.

When weathered Pocahontas coal is included in the blend, we found that the coke produced contained an excessive amount of braize. In addition, the coke had definitely lower tumbler stability and hardness factors. When this poor quality coke was charged to the blast furnace, there was a decided decrease in the amount of wind blown and in iron production.

This data shows that a definite change in the coking quality of the low or high volatile coal used in the blend produced a definite change in the physical and chemical properties of the resulting coke. The conventional physical tests, per cent + 2 in. coke, shatter, tumbler stability and hardness values are shown to be a satisfactory yardstick for measuring differences in the quality of the coke and their influence on blast furnace iron tonnage.

TONNAGE OXYGEN FOR INCREASED IRON AND STEEL PRODUCTION

By JULIUS H. STRASSBURGER, Manager, Department of Service and Maintenance, Weirton Steel Company, Weirton, West Virginia

▲ THE idea of using oxygen in iron and steelmaking is not new as patents were issued as far back as 1867 and 1869 for its use on bessemer converters, and subsequent patents were issued repeatedly up to the present time. During the decade following World War I the use of oxygen metallurgically was given wide study, but actual use of oxygen for metallurgical use did not develop commercially at that time, due to the prohibitive cost of oxygen. More recently, methods have been developed for the production of tonnage oxygen at reasonable cost, and a new tool was made available for expanding the production of iron and steel.

The Weirton Steel Company is using the bessemer blown metal process for producing open hearth steel so that the use of oxygen in steelmaking is possible in the blast furnaces, bessemer converters, and the open hearth furnaces. Four two-ton per day 99½ per cent purity oxygen plants were installed in December, 1945, for furnishing oxygen for welding, cutting and scarfing. The excess oxygen available from this installation was used for experimental work in the bessemer and open hearth departments. No oxygen was used for experimental work at the blast furnaces as an insufficient sustained quantity was available for this type of work. A 400-ton per day oxygen plant is now under construction for furnishing approximately 10,000,000 cubic feet per day of 93 to 95 per cent oxygen for use as the first step in increasing the production of steel by the use of oxygen.

German experiments have shown that oxygenation of the blast in the blast furnace results in a saving of coke, greater iron production, smoother working, and a reduction in flue dust. Figure 1 shows the possible percentage increase in the production of a blast furnace based on varying the percentages of blast enrichment. This estimated production curve indicates that the increase in production obtained by the use of oxygen on blast furnaces as designed at present may not increase continuously with greater percentages of oxygen, but at about 27 per cent or 28 per cent oxygen content in the blast a maximum benefit may be obtained after which the use of oxygen might actually show a lesser benefit.

Preheating of the blast will still be necessary to maintain heat input to the furnace. A moderate saving of coke with an increased iron production of from 10 per cent to 20 per cent will be possible dependent upon the amount of enrichment. The operation of the furnace with oxygen should show lowered flue dust per ton of iron produced with lowered top gas temperatures, lowered top gas volumes, but higher Btu content of the top gas. The use of oxygen should make the blast furnace operation smoother with the ability to adjust temperatures quickly maintaining hot iron with possibly lower sulphur in the pig iron.

The next step in the use of oxygen metallurgically is in the bessemer converter. Actual tests have been made at Weirton with a limited supply of oxygen for oxygenating the blast on a 25-ton vessel.

The experimental use of oxygen on the bessemer converter was carried on at Weirton during a two-month period. The bessemer converters are used for producing blown metal for final refining in the open hearth furnaces. The metal is blown down to approximately one per cent carbon. The oxygen used was the excess available from four 2-ton per day, 99½ per cent purity oxygen plants which normally supply oxygen to the cutting, welding, and scarfing operations. The maximum amount of oxygen available for the experimental heats at the two 25-ton bessemer converters amounted to 1600 cfm with a blast volume of 32,000 cfm. A maximum oxygen content of 24.7 per cent was possible as compared with the German practice of 30 per cent to 31 per cent which would require 4000 cfm of oxygen for a 25-ton vessel.

Figure 1 — Possible increase in pig iron production with varying amount of oxygen in blast.

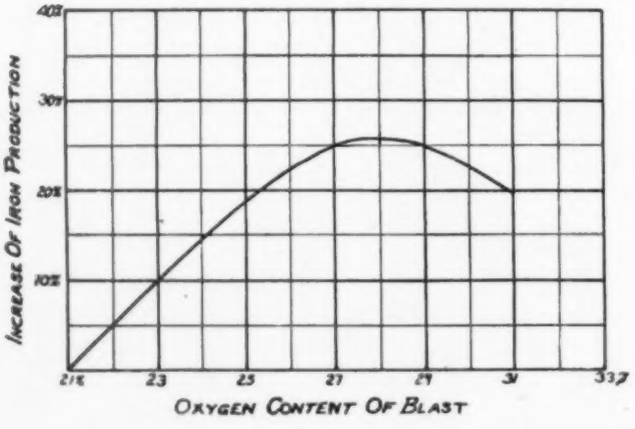
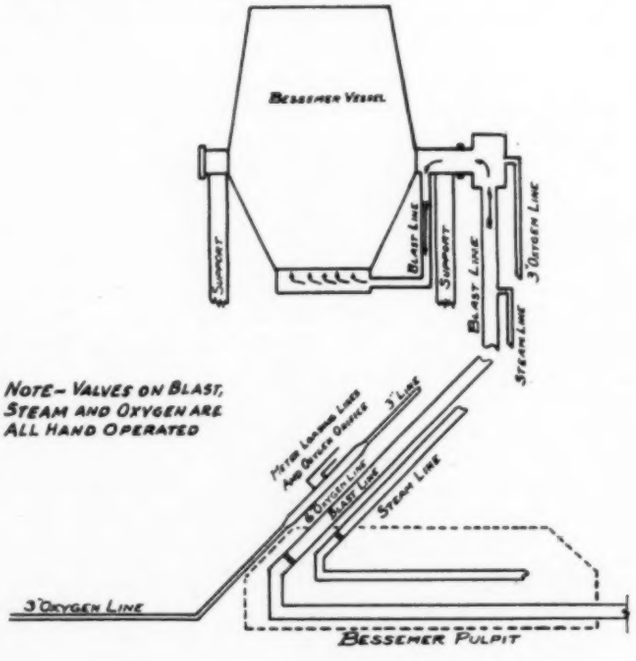


Figure 2 — Arrangement of bessemer at Weirton used in blowing metal with oxygen.



The oxygen, at a pressure of 20 psi at the converter, was turned on with the blast as the converter was being rotated upwards at the start of the heat and in the first series of experiments the oxygen was left on during the silicon and carbon blows until the scrap was melted. The color of the flame was different than with air and was characterized by an intense, white glare. In these first experimental heats additional scrap amounting to 20 per cent more than normal was charged and the blown metal produced was entirely satisfactory for the open hearth department. The average data on these oxygen heats as compared with normal practice at that time are shown in Table I herewith.

TABLE I

Oxygen Test on Bessemer Converter

	Without oxygen	With oxygen
Charge (lb):		
Hot metal	45,000	45,333
Scrap	7,000	8,416
Total	52,000	53,750
Blow time (min)	10	7½
Oxygen used (cu ft)	.....	6,937
Time oxygen (min)	.....	4-26″
Oxygen (cu ft per min)	.....	1,568
Prod (tons per min)	2.6	3.58

This tabulation shows a decrease of 25 per cent in blowing time and an increase in production of 37.5 per cent in tons of blown metal produced per minute including a 20 per cent increase in scrap charge. This performance was obtained with only 258 cubic feet of oxygen per ton of blown metal as compared with German practice of 800 to 850 cubic feet of oxygen per ton where ample oxygen was available for full scale use.

Experiments were then made by introducing the oxygen for about 2½ minutes after the scrap was melted with no oxygen used during the scrap melt in an effort to lower the final silicon and possibly obtain an improved blown metal. As a result of this work, a final series of tests were made with the oxygen in the bessemer for three to four minutes during the scrap melting period and one to two minutes at half rate after the carbon blow for final reduction of silicon. These heats were made with a normal scrap charge approximately the same as when blowing air and the results of this series of tests are shown in Table II herewith.

The data of Table II indicate a decrease of 29.5 per cent in blowing time and over a 40 per cent increase in tons of blown metal produced per minute with 216 cubic feet of oxygen used per ton. The oxygen was turned on at the start of all blows for three to four minutes until the scrap was melted with an oxygen rate of 1600 cfm and after the carbon blow the oxygen was again turned on for one to two minutes at half rate of 800 cfm in order to obtain final silicon reduction. The results of this practice showed an exceptionally good quality of blown metal with a clean, white, hot iron and very good slag separation. The silicon was reduced from a normal of 0.010 to 0.006.

From the information obtained up to date we can definitely say that the use of oxygen in the open hearth

TABLE II

Oxygen Test on Bessemer Converter

	Without oxygen	With oxygen
Charge (lb):		
Hot metal	45,500	45,917
Scrap	9,000	9,000
Total	54,500	54,917
Blow time (min)	9	6.34
Steam on with oxygen (min)	.....	1.62
Oxygen used (cu ft)	.....	5,950
Time oxygen (min)	.....	4
Oxygen (per min)	.....	1,600-3 800-1
Prod tons (per min)	3.00	4.33

fuel burner is of greater advantage for an open hearth practice using a high scrap charge as compared with one using a high iron charge. The results will vary considerably due to the size of the furnaces and shop layout. Some plants have tried the use of oxygen in the checker chambers for enriching the main air supply to the furnace. The results of this practice have not been as good as when applying the oxygen directly in the fuel burner.

At Weirton, with an open hearth furnace making 210-ton heats, the input of fuel oil during the scrap melting period increased from a normal of 480 gallons per hour when not using oxygen up to 700 gallons per hour when using approximately 900 cfm of oxygen in the burner. The time of heat from charge to tap was shortened from a normal of 14 hours down to 10 hours with a corresponding increased production rate of 21 tons per hour as compared with a normal rate of 15 tons per hour. The percentage increase in production rate amounted to 40 per cent and the fuel consumption was lowered by 17 per cent, equivalent to a net saving of five gallons of fuel oil per ton of ingot production. The total oxygen used during a heat amounted to about eight tons spread over a period of four hours. These results were obtained with one furnace only using oxygen in a 12-furnace shop. The benefits possible with a larger number of furnaces using oxygen would probably not be as great as obtained from this one furnace experiment, due to present limitations of charging equipment for getting the scrap into the furnace as fast as it can be melted with an oxygen accelerated flame.

Some thought is being given to the melting of scrap in a separate furnace by the use of oxygen and the charging of this molten scrap into the open hearth in order to minimize the scrap charging time. However, for the immediate future, taking into consideration the limitations of charging facilities and the present day refractories obtainable, a more conservative usage of oxygen will probably still result in an appreciable increase in open hearth production with a moderate fuel saving. In the case of a 200-ton open hearth furnace, the use of about 600 cfm of oxygen during the scrap melting period (approximately four hours) should produce an increase in open hearth furnace production of about 20 per cent with a 10 per cent to 15 per cent decrease in fuel consumption. This practice would require about six tons of oxygen per heat of steel or 720 cubic feet of oxygen per ton of ingots. The economics of this proposed practice, based on an oxygen cost of $5.00 per ton, is

TABLE III

	Fuel oil at 5c per gallon	Fuel oil at 10c per gallon
Size of heat — tons	200	200
Oxygen used per heat — tons	6	6
Fuel oil saving at three gallons per ton — gallons	600	600
Cost of oxygen per heat	$30.00	$30.00
Saving in fuel oil per heat	$30.00	$60.00
Net saving per heat	.....	$30.00
Net saving per ton of ingots	.....	$ .15
Increased rate of production	20%	20%

compared in Table III with fuel oil priced at both 5¢ and 10¢ per gallon.

Table III shows that the use of a moderate amount of oxygen with the fuel on an open hearth furnace will pay its own way with oxygen at $5.00 per ton and fuel oil at either 5¢ or 10¢ per gallon. In both cases an estimated increase in production of 20 per cent should be obtained with no saving in cost with fuel oil at 5¢ per gallon and a 15¢ per ton saving in cost with fuel oil at 10¢ per gallon.

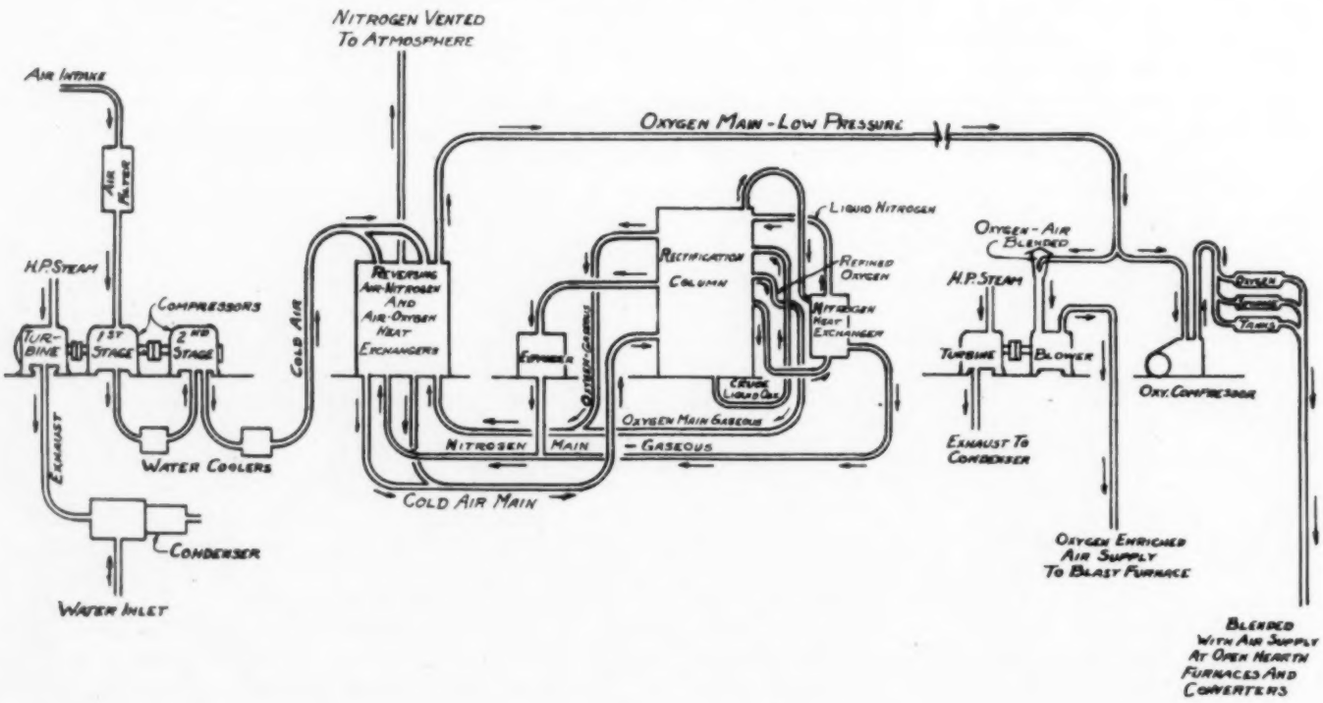
With the increased cost of liquid fuels it is highly possible that oxygen can be used extensively with gaseous fuels or a combination of gaseous and liquid fuels so that the high flame temperatures and tonnage rates possible with straight liquid fuels can be maintained. The use of straight liquid fuels as compared with a combination of liquid and gaseous fuels has in the past shown that an increase of 7 per cent to 8 per cent in ingot production is possible. The ability to maintain this production rate with combination firing with the help of tonnage oxygen should show attractive savings with fuel oil at 10¢ per gallon (66.7¢ per million Btu) and with gaseous fuels priced at 35¢ per million Btu. Table IV is an analysis of this proposed practice. This comparison of combination firing with the use of oxygen versus oil firing without the use of oxygen shows a possible saving of 40¢ per ton of ingots with oxygen at $5.00 per ton. It is our opinion that the use of oxygen with combination firing should be attractive from a fuel cost standpoint.

TABLE IV

	Oil fired	Combination oil and gas firing
Size of heat — tons	200	200
Heat consumption per ton of ingots — Btu	3,700,000	4,000,000
Fuel oil required per ton — gallons	25.5	12.5
500 Btu gas required per ton — cu ft	.....	4250
Cost of fuel oil per ton	$ 2.55	$ 1.25
Cost of gas	.....	$ .75
Total fuel cost	$ 2.55	$ 2.00
Fuel saving — per ton	.....	$ .55
Amount of oxygen required — tons	.....	6
Cost of oxygen at $5.00 per ton	.....	$30.00
Cost of oxygen per ton of ingots	.....	$ .15
Net saving in fuel cost minus oxygen cost — per ton	.....	$ .40
Production rate — tons per hour	15	15

The Weirton Steel Company is now in process of installing an oxygen plant with a capacity of 400 tons per day of 93 per cent to 95 per cent purity oxygen. This plant is diagrammatically illustrated in Figure 3. The plant will occupy an area of approximately 70 ft x 90 ft and will utilize the low pressure cycle for producing

Figure 3 — Weirton Steel Company oxygen plant.



oxygen with a steam driven centrifugal compressor supplying air at approximately 100 pounds pressure absolute to reversing heat exchangers for cooling the air. The next step is the fractional distillation of the oxygen from the liquid air in a two-stage rectification column. The plant also includes centrifugal expanders which will be loaded with electrical generators for supplying the necessary refrigeration. The oxygen produced from this plant will be so piped that it can be supplied to:

1. The intakes of four turboblowers supplying cold blast to three 1200-ton blast furnaces.
2. To a 300-pound storage bank of 400,000 cubic feet capacity which will be piped to supply oxygen to:
   a. Open hearth furnaces for use in the combustion of fuel.
   b. Open hearth furnaces for use in decarburization of the bath.
   c. Bessemer converters for enriching the blast.

The oxygen supplied to the blast furnace turboblowers will be at two to three pounds pressure as produced by the oxygen plant proper. The oxygen supplied to the storage bank for the open hearth and bessemer operations will be compressed in four stage compressors with a delivery pressure of 300 pounds per square inch. One of the main features of this oxygen plant is the 800-pound, 800 F steam supply to the turbo air compressor as a means of obtaining cheap oxygen with a low compression cost.

SOME PRACTICAL ASPECTS OF DIRECT OXIDATION IN THE BASIC OPEN HEARTH PROCESS

By FRANK G. NORRIS, Statistical Metallurgist, and EDWARD B. HUGHES, Foreman, Open Hearth Metallurgy, Wheeling Steel Corporation, Steubenville, Ohio

▲ EXPERIMENTS at the Steubenville plant of Wheeling Steel Corporation to determine the feasibility of direct oxidation began in September 1946 and continued to the end of the year. Facilities were extended to serve more furnaces. Various practices were investigated and an attempt was made to correlate the rapidity of carbon oxidation with the amount of oxygen used.

On the first of January 1947, direct oxidation was adopted as standard operating procedure in the open hearth. For the next three months the percentages of heats made by direct oxidation almost doubled each month. Starting just over 20 per cent in January, it was over 40 per cent in February, and almost 80 per cent in March. During 1947, 4758 heats were made by indirect oxidation. The average overall consumption of oxygen was 7200 cu ft per heat.

During the past year several studies have been made in order to improve the knowledge of the direct oxidation process and to compare it with other practices. The actual rate of carbon drop is not as important in this study as the comparative rate. Some carbon would be eliminated if no oxygen were used, the rate depending chiefly on the carbon content. Therefore, direct oxidation can be credited only with the increase in rate rather than with the total carbon drop during the period of blowing. This increase in rate is defined as comparative rate.

For purposes of keeping an accurate record of the benefits derived from direct oxidation, the following method was used to compare the speed of decarburization by direct oxidation with the speed of decarburization by ore.

$$\text{Comparative rate} = \frac{R_d - R_i}{R_i}$$

where R_d = Rate of decarburization by direct oxidation expressed in points of carbon removed per minute.

R_i = Rate of decarburization by indirect oxidation (ore) expressed in points of carbon removed per minute.

This formula indicates the comparative rate for decarburization at any desired carbon content of the steel bath. Strictly speaking, R is the instantaneous rate or in other words, the slope of the carbon elimination curve at any carbon content. If R is replaced by the average rate between two carbon values, comparative speed is expressed by the equation:

$$\text{Comparative speed} = \frac{T_i = T_d}{T_d}$$

where T_i = Time required to decarburize from carbon concentration A to carbon concentration B by indirect oxidation.

T_d = Time required to decarburize from carbon concentration A to carbon concentration B by direct oxidation.

The general shape of the two carbon drop curves resulting from direct and indirect oxidation is the same between the two carbon concentrations. Therefore, use of average rates does not introduce a serious change. This equation furnishes the basis for a quick estimate which is practically equivalent to an exact computation of the comparative rate.

A series of heats taken about the middle of a campaign on one furnace was selected for study. The series consisted of 52 consecutive heats which were charged with 60 to 62 per cent hot metal, scrap from our own plant, and sintered ore. Some heats of this series had unavoidable delays unrelated to the use of oxygen, such as traffic congestion and crane breakdown. Other heats made extremely fast time due to improved methods of combustion. Rejection of such heats left 35 heats for the present study.

Some of the heats used oxygen in jets for scrap melting and some used air as well as oxygen for direct oxidation of the bath. The two groups of heats using the greatest amount of air had the highest comparative speed.

There is a general tendency for an inverse relation between comparative speed and total oxygen consumption. The best production measured by tons per hour results from use of the larger amounts of oxygen (14,000 to 17,000 cubic feet per heat). The greatest benefit from the use of oxygen measured by comparative speed is

found in the heats with smaller total oxygen consumption.

Where a free choice is possible, it is logical to use more oxygen and make faster heats even though the benefit compared with ore is not as great. In some of the heats in this study a free choice was not possible because of curtailment of the supply of oxygen.

There was a general tendency for increase in tons per hour and decrease in fuel as comparative speed decreases. A choice must be made between high production and the maximum benefits from a given amount of oxygen. Failure to recognize these slightly contradictory influences has caused some confusion. The present study shows fairly well the factors contributing to comparative speed.

There was an increase in heat time with decreasing comparative speed. This general relation is the one that is to be expected.

There seems to be a fairly good relation between the percentage of charge ore and the comparative speed of carbon elimination. All of these heats were made with about the same iron charge, therefore the amount of charge ore variation was held at a minimum. There is a rather definite downward trend from 8¾ per cent charge ore in heats with high comparative speed to close to 7½ per cent ore in the charge for heats with speed about equal to that of heats worked with ore.

The group of heats with the greatest comparative speed also had a longer time for charging the scrap. There was practically no trend for the rest of the heats. Thus the relation to the use of air, amount of charge ore and the longer charging time seem to point to one conclusion. The comparative speed is greater if there are other sources of oxygen in the early stages of the heat.

At high carbon, ore is sufficiently fast so that possible improvement with direct oxidation is relatively small. At lower carbon content, direct oxidation has a greater effect in increasing the comparative speed.

The factors which affect or are affected by the comparative speed of decarburization are:

1. Tons per hour on a charge to tap basis
2. Cubic feet of oxygen used for decarburization
3. Percentage of scrap in the charge
4. Percentage of ore in the charge
5. Carbon content of the bath at start of direct oxidation.

Thus far the inter-relations of these factors have not been mentioned.

In deciding the best combination of charge ore, iron and scrap, choice must be made between production in terms of tons per hour and best utilization of feed ore and oxygen in terms of comparative speed. A long time view forsees the use of large amounts of cheap oxygen made on a tonnage scale from an inexhaustible supply. This cheap oxygen can be used to supplant an ever dwindling supply of open hearth feed ore.

All experimental work in this study was conducted on the same furnace. A study of the factors affecting heat time is interesting in pointing out possible causes for variations in heat time which are independent of the effect of comparative speed.

The original series of 35 heats were arranged in order of decreasing heat time. Averages were calculated for groups of five successive heats in this arrangement. Heat time was tabulated in minutes for convenience.

There is, naturally, a close relation between tons per hour and heat time. The slight variations which exist indicate less satisfactory results if tons per hour were used for the basis of the study.

The factors which appear to have the strongest relation to heat time are:

1. Percentage of scrap charged.
2. Percentage of feed ore.
3. Percentage of carbon at start of direct oxidation.
4. Volume of deoxidating gases used for direct oxidadation.
5. Volume of oxygen used to melt scrap during charging the furnace.

Table I shows a brief summary of the studies of comparative speed and heat time. These studies were begun with no previous experience regarding what factors might be important. The data collected were as accurate as possible. A step by step analysis was made of these data. This paper gives in outline form the method of this analysis. Many of the factors are related to some of the other factors. There is general agreement between the factors that favor high comparative speed and those that accompany short heat time.

The fundamental factor under control of the operator is the condition of the bath at the start of direct oxidation. The best comparative speed results when the bath is not too high at the start of direct oxidation. The other relations logically result from this statement. In this series of heats a slightly increased amount of charge ore means that the heats will melt a little closer. The heats with higher charge ore also have a slightly smaller amount of scrap in the charge. Scrap charge is shown as a sub-head under high charge ore in Table I because in this series of heats it was not changed independently. Changes in amounts of scrap accompanied changes in charge ore.

TABLE I — SUMMARY OF RESULTS

Comparative Speed favored by:

1. Not over 0.30 carbon at start of direct oxidation.
2. High charge ore.
   2a. Low scrap charge.
3. Low amount of oxygen for direct oxidation.

Short Heat Time favored by:

1. A close melt.
   1a. Higher scrap charge.
   1b. Low feed ore.
2. A large amount of oxidizing gas (oxygen and air) for direct oxidation.

The chief problem during the experimental period (i.e. the last three months of 1946) was to explore the possibilities of the economical use of direct oxidation in a low carbon shop.

The problem of the year 1947 has been to allocate a limited supply of oxygen so as to secure the greatest benefits. An understanding of comparative speed as outlined above has been developed during this period. Comparative speed does not tell the whole story of the benefits derived from direct oxidation. Two other very tangible benefits are heat time and temperature.

From the very beginning of this work most of the lowest carbon grades have been made by direct oxidation. This tendency still persists. All of the extremely low carbon heats are made by direct oxidation. Heats over 0.12 per cent carbon are made by working with ore alone. In the other carbon grades there is overlapping of the two practices, some heats being made by direct and some by indirect oxidation, but the tendency is for more of the lower carbon heats to be made by direct and more of the higher carbon grades to be made by indirect oxidation. Because of this tendency and for other reasons, the comparison of heat time is made by grades. On a grade by grade comparison the indirect heats are from 5 to 10 per cent longer than direct oxidation heats. On single heats we have, of course, shown results that can be interpreted as even more favorable for direct oxidation. Some early trials reported by Slottman and Lounsberry are interpreted to show as much as 25 per cent improvement in heat time. Over an extended period we have not been able to do this well. As more oxygen becomes available, we hope to do better.

In the above study the direct oxidation heats include only those in which carbon elimination was the chief reason for the use of direct oxidation. Another important use of direct oxidation in our shop is to help to increase the temperature. The direct oxidation group has more heats without skull and fewer heats with skull. There is, however, considerable overlapping of the two groups. Most of the heats that were made by either method are poured with a clean ladle. If we were having more trouble from skull there would be greater room for improvement. The entire effect on skull is difficult to show. Practically all of the doubtful heats are in the direct oxidation group because of the melter uses one or two pipes of oxygen (if it is available) in case he needs extra temperature.

ECONOMIES

Savings from faster heat time are estimated at $1.25 per minute as the cost of operating an open hearth furnace. The benefits of increased yield are based on $40 per ton. This figure is admittedly an estimate which includes several factors other than ingot cost. It is quoted so that each reader may make similar computation using figures appropriate to his own situation. The price of the oxygen used throughout 1947 was $3.35 per 1000 cu. ft. The average amount per heat is estimated as the total cubic feet of oxygen divided by the number of heats using oxygen and is 7200 cu. ft. per heat which makes the cost of oxygen $24.10 per heat. Some heats, of course, used more than others. The heats using direct oxidation for temperature alone used about 4000 cubic feet of oxygen at a cost of—4000 cu. ft. at $3.35=$13.40.

Over a period of seven months the average skull was 614 lbs. for 1646 of these heats compared to 902 lbs. for 769 heats using only indirect oxidation, or a saving of 285 lbs. This represents a direct saving of $0.142 \times 40.00 = \$5.67$ due to increased yield. The tangible benefits of improved quality are more difficult to estimate. A flaring stream or leaky shut off due to skull in the well causes poor surfaces as well as pit loss. A monetary value cannot be assigned to trouble that has been averted. The oxygen used to prevent skull is believed to have been justified as insurance against pouring trouble.

There were 1810 heats using direct oxidation for elimination of carbon using an average of 11,150 cu. ft. per heat or a value of $37.40 per heat. As discussed above, the savings in heat time depends upon grade. A conservative estimate covering all grades is one half hour. This means that the saving in operating cost pays for the oxygen consumed.

There was an average skull of 477 lbs. on 1810 heats using direct oxidation for elimination of carbon. Compared with indirect oxidation, there were considerably fewer heats with 2,000 to 10,000 lbs. skull.

The larger amount of oxygen used for carbon elimination is also more effective in avoiding excessive skulls. Compared with the indirect oxidation heats, the difference in average skull was 425 lbs., or a saving of $0.212 \times \$40 = \$8.48$ per heat or the cost of approximately 2500 cu. ft. of oxygen. The larger savings in the group of heats using more oxygen supports the conviction that with greater consumption forseen in 1948 the economies will be correspondingly increased.

SUMMARY

1. Previous experimental heats demonstrated the faster rate of carbon elimination made possible by using direct oxidation. This work was based on instantaneous rates at a given carbon content. The present paper reports some of the experiences during the development of direct oxidation from pilot scale operation to standard practice for a majority of the shop production.

2. The benefits of direct oxidation are evaluated in terms of comparative speed, faster heat time and decrease of skulls.

3. One important factor governing comparative speed is the carbon content at the beginning of direct oxidation.

4. Over a large group of heats made by direct oxidation, a decrease of heat time from 5 to 10 per cent is shown depending on the carbon grade.

5. Short heat time is favored by a close melt and by relatively large amounts of oxygen.

USE OF OXYGEN FOR DECARBURIZATION AND MELTING IN THE ELECTRIC FURNACE

By J. H. EISAMAN, Superintendent, No. 2 Electric Furnace Shop, South Works, Carnegie-Illinois Steel Corporation, Chicago, Illinois

Oxygen as an aid to steelmaking has, since its initial application to electric furnace practice at South Works early in the thirties, completely replaced ore or scale for carbon elimination. This change has resulted in a number of advantages:

1. Increased tons per operating hour have been obtained because of rapid carbon elimination from the liquid steel bath.

2. An improvement in alloy steel quality has been obtained.
3. Cost savings in the manufacture of stainless steels are most apparent. In this grade the use of oxygen has permitted larger quantities of stainless steel scrap to be charged. Oxygen has also contributed to improved recovery of chromium from stainless scrap, and a measurable shortening of the heat time.

The South Works management early realized the possibilities inherent in the use of oxygen in the electric furnace. This policy resulted in a series of laboratory experiments with a 500-pound arc furnace. The knowledge so derived was used in experiments on 30-ton arc furnaces, all of which culminated in the Chelius patent for the manufacture of stainless steels with oxygen.

Oxygen is obtained from the plant system at a line pressure of 120 psi, which provides a maximum flow of approximately 15,000 cubic feet per hour per outlet. The lances are common one-half inch pipe, covered with patching (ground firebrick and ganister) and wrapped with cotton tape to hold the patching intact. The finished lance is not dried before placing in the furnace, since the heat of the furnace dries it sufficiently as it is being used. A lance prepared in this manner lasts approximately two hours. The lances are introduced through wicket holes in the doors, with the end of the lance through the slag, but not into the metal. By so doing, the oxygen flowing from the lance impinges on the metal at the slag-metal interface.

In some shops, the rate of input and also the rate of carbon reduction are faster than can be justified at South Works at this time, not only from an oxygen efficiency viewpoint, but also from the observation that extremely fast carbon reduction tends to produce a melt that is very difficult to control. With respect to large furnaces, it seems at this time that, from an over-all viewpoint of the efficiency of oxygen use, refractory life and control of the bath, extremely high rates of oxygen input are possibly not the most economical in the long run.

STAINLESS STEELS

A recent run of forty-four consecutive heats was made up on a type 70 Heroult furnace, making 0.12 per cent maximum carbon with approximately 18.00 per cent chromium, 9.00 per cent nickel stainless steel heats. Table I shows the pertinent operating data.

TABLE I

Stainless 0.12 per cent max C

Average heat size	83.2 tons tapped
Average heat size	78.9 tons ingots
Chromium recovery (from stainless scrap)	88.3 per cent
Average melt carbon	0.163 per cent
Average carbon reduced	0.100 per cent
Average oxygen used per ton	163.9 cubic feet
Average power consumption per ton	449. kwh (tapped tons)
Average power consumption per ton	474. kwh (ingot tons)
Average heat time tap to tap	11.51 hours
Average heat time power to tap	9.43 hours
Tons per operating hour	7.23 tons
Tons per furnace hour	8.81 tons

Other recent runs in a furnace of the same size have been made, including many heats of 0.08 and 0.07 per cent maximum carbon. The stainless scrap charged in these heats was approximately 50 per cent on the basis of tapped weight. The average chromium recovery from the scrap was 78 per cent. Approximately 350 cubic feet of oxygen per ton was used.

From the experience at South Works the performance as indicated by the above data could not possibly be equalled by carbon reduction with ore or scale.

The advantages of using oxygen in the manufacture of stainless steel are:

1. High percentage of stainless steel scrap may be used.
2. High percentage of recovery of chromium from the scrap may be obtained.
3. Kilowatt-hours per ton are lowered since the oxygen-chromium reaction is exothermic, thus providing additional heat.
4. Tons per hour are increased.
5. Material handling costs are lowered since no ore is required and since there is less waste slag to be handled.
6. Due to the high residual chromium in the bath, fewer off-heats because of chromium content occur, since errors in either weighing or sampling of the bath are relatively of less importance when adding chromium to a bath with a 12.00 per cent residual to meet an 18.00 per cent specification than with a low residual chromium bath.
7. Fewer off-quality heats occur in the straight chromium grades.

ELECTRIC FURNACE QUALITY CARBON AND ALLOY STEELS

Some years back the normal practice was to melt to the low side of the carbon specification, with little or no oxidation, in an effort to obtain maximum alloy recovery from scrap. It became increasingly evident that the bath had to be oxidized to obtain clean, sound steel. It then became common practice to melt above the carbon specified. Ore was added with the charge or additions of ore were made when the bath was melted in order to produce a good boil.

At South Works, the current practice consists of charging sufficient coke to melt about 0.20 to 0.30 per cent carbon above the specification. If available, 80 per cent of the charge is alloy scrap.

TABLE II

Alloy Steels

Average heat weight (ingots)	44.7 tons
Tap to tap time	7.48 hours
Power on to tap time	6.07 hours
Tons per operating hour	5.98 tons
Tons per furnace hour	7.27 tons
Kilowatt hours per ton	527.0
Carbon reduced	0.274 per cent
Time for carbon reduction	48.0 minutes
Cubic feet of oxygen	164.0 cubic feet per ton
Manganese residual	0.262 per cent

When melting alloy steel, as soon as the heat is sufficiently melted to obtain a test, oxygen is added and the carbon reduced sufficiently below the specification limit to permit the use of high carbon ferro alloys.

Carbon reduction by oxygen seems to be a more reliable method of obtaining low hydrogen content in the steel, because of decreased introduction of hydrogen and the purging action of the oxygen.

Table II shows the results of 515 recent heats of alloy steel made with the use of oxygen.

SINGLE SLAB ALLOY STEELS

The practice at South Works on single slag alloy steels consists of charging 80 per cent alloy scrap, if available, ordinary carbon scrap and sufficient coke for the bath to melt theoretically 0.15 to 0.20 per cent over the carbon specified. Enough burned lime is charged to produce a lime-silica ratio of 3. When the heat is melted a test is taken and oxidation is begun with oxygen. When the carbon is low enough to allow for high carbon ferro alloys, the heat is blocked with aluminum, another test is taken, and when final analysis is obtained, additions are made and the heat is tapped.

SINGLE SLAG RIMMING STEELS

During the recent shortage of open hearth steels, the considerable electric furnace capacity available has resulted in the production of rather large tonnages of single slag carbon steels in the electric furnace, particularly of the rimming type, using oxygen as the only oxidizing agent.

Normally the scrap charged in the rimming heats is of such a physical form that the original charge and two recharges are sufficient to get the required amount of scrap into the furnace. Enough burned lime is added with both the original charge and the recharge to maintain a lime-silica ratio of about 3. Bottom and bank maintenance on this grade is very slight.

EXPERIENCE TO DATE ON IRON PRODUCTION BY METHODS OTHER THAN COKE BLAST FURNACE: DIRECT REDUCTION

By EARLE C. SMITH, Chief Metallurgist, Republic Steel Corporation, Cleveland, Ohio

▲ THERE are four direct reduction methods with economic background sufficient to justify examination at this time: the Chinese "Shansi" method of iron production, the Hoganas process of Sweden, the Wiberg process of Sweden, and the Johannsen process of Germany, usually known as the Krupp-Renn process.

The Hoganas also is making iron for powder metallurgy; the Wiberg is producing stock for melting; and the Krupp-Renn is idle due to lessened need for iron units in the German industry.

THE CHINESE METHOD

In China in the Ping-ting-chou area of Shansi Province, which lies 250 miles southwest of Peiping, direct reduction of iron ore to iron is an ancient industry. The Chinese mine the ore and the coal locally. The process consists of enclosing in a clay tube a mixture of ore, coal and partially burned coke salvaged from previous operation. Each tube is a few inches in diameter and about three feet in length. A floor covering a few square feet is laid out with broken tubes salvaged from previous operation. This provides for the entrance of air from below the furnace to meet the combustion requirements. Standing on end on this floor are the tubes, each filled with a mixture of ore, coal and coke. The tubes, packed in fuel, are then surrounded by a crude wall to make a furnace of the whole. Reduction is accomplished by setting fire to the mass of fuel in and surrounding the tubes, and burning for three or four days. The bottom of the mass gets hot enough to cause the iron to fuse into a bloom. The upper portion is simply sponge iron in small or large masses, depending upon contact. It may be used for metal shot in the old muskets used in that area. The bloom is forged into useful commercial articles, needed by the people living there. Iron shot, melted in crucibles with coal, provides for iron casting. The widely known Chinese cooking pot is a good example.

THE SWEDISH METHODS

At Hoganas, in southern Sweden, is a very efficiently managed plant, reducing magnetic concentrates by the process invented by Sieurin. The present production is about 20,000 tons per year, and is of chief importance in the powder metallurgy industry.

In brief outline, iron ore, in this case magnetite concentrates, is packed in alternate layers with coal and coke braize in cylindrical refractory containers, which are placed in a furnace of a similar type to the ring furnaces used for firing refractory bricks. The containers remain stationary in the furnace while hot gases are circulated over them.

The ore comes from Lulea during the open water shipping season and is dried for mixing, as in the reducing material. The charging is done, and the charged containers are put into the furnaces in batches. The furnace can take 35,000 containers and the reduction period is 12 days total, of which 8 days are the effective firing time. The maximum temperature is about 2200 F.

There is a very complete plan laid out by an American engineer, for a modernized Shansi-Hoganas process which involves roasting, magnetic concentration, carborundum containers, continuous tunnel kiln reduction, and high pressure press briquette equipment. His figures indicate that, with less than $1,000,000 plant investment and working capital, 36,500 gross tons of iron cakes could be produced and marketed at a profit, if the selling price were approximately $30.00 per gross ton. This plan is about one year old, very complete in its detail and very well thought out, and indicates that there still exists the urge to modernize this Chinese process.

Of enough importance to warrant additional present day expansion, there is operating also in Sweden the process developed by Professor Wiberg, and brought into full production by Stora Kopparberg at the Soderfors plant. At present, additional capacity is being added at other plants in Sweden. In this process a shaft furnace, very similar to a blast furnace, is charged with sinter. The upper portion of the furnace provides for preheating the descending mass. The process depends upon forming gas by gasifying charcoal in an arc electric gas producer. This gas is heated by the electric arc to about 1800 F, fed into the reduction furnace in the lower portion of the stack, picked up for recirculation in the upper half of the furnace and sent back through the hot charcoal to convert the water vapor and carbon dioxide into hydrogen and carbon gases. A portion of the stack gas is burned near the top of the furnace to pre-heat the descending charge preparatory to reduction.

KRUPP-RENN

In about 1930, the German iron industry undertook a study of the application of the results obtained in smelting certain high iron zinc ores to beneficiation of lean iron ores. The immediate predecessor was the Waelz kiln, and by 1930 possibly 1,000,000 tons of ore had been treated by such furnaces.

The Goering Werke kilns were Krupp built and operated. Apparently the performance never was cheap enough to suggest that the Goering Werke take on this difficult, expensive operation. It has been indicated by some sources that other metallurgical problems of that plant were simplified by making another firm bear an undue burden. The mental process that permits a government-owned operation, or the plant of a political favorite, to stand out is not peculiar to Germany, or even confined to the European continent.

Three rotary kilns 70 meters (230 ft) by 4.2 meters (13.8 ft) are built in a row. The plant was designed for two pairs of two kilns each, but one kiln was not constructed. The shell of each kiln consists of heavy sheet, riveted. The kilns are lined for the entire length with refractory bricks. The material for the charging zone and the reduction zone did not cause any difficulties. Fire clay brick of medium quality 32 to 35 per cent Al_2O_3 are used in the charging zone, and the best quality bricks 37 to 40 per cent Al_2O_3 in the reduction zone. The chief problem was in the sponge zone, where a highly siliceous slag, high temperature during the working period, influx of cold air and rapid changes of temperature during the checking period (5 minutes every hour), demand the utmost of brick. After several failures, Krupp claimed to have found a suitable material, the so-called Kartolin manufactured by Messrs Didier.

The most satisfactory lining for the balling zone at the outlet was a quartz slate or schist. The lining was made of long blocks. Our American acid bessemer operators have had a long experience with the usefulness of this natural refractory in acid slag work. The Krupp-Renn furnace slags were about 60 per cent SiO_2, 18 per cent Al_2O_3, 10 per cent CaO, 5 per cent MgO and 5 per cent FeO. These slags, pasty at operating temperatures, were somewhat more liquid than the pellets or balls of metal, for the metal with a carbon content of less than one per cent had a high melting point. The mass of slag and metal was dumped into water, crushed and separated. The metal "Luppen," the name coined from the old European name for a bloom of iron, "Loup," was used for this modern crude product. The sulphur content depended upon the fuel, but 0.50 per cent sulphur was common. Phosphorus likewise depended upon raw material, and one per cent was not uncommon. On the whole, it was a good beneficiation furnace. The product could be used in steel furnaces but was really only fit for blast furnace scrap.

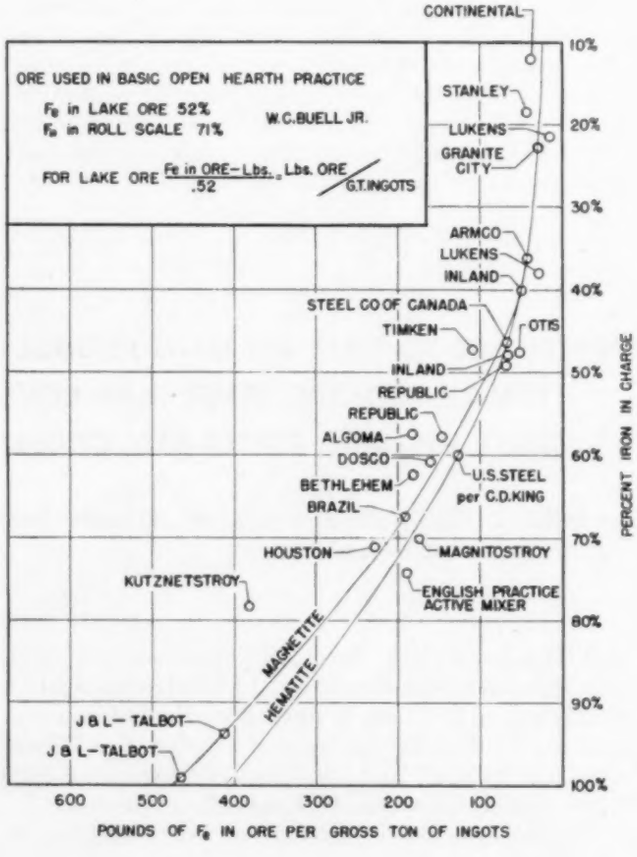
When used on nickel silicates ores, the process provided metal with nearly 10 per cent nickel from ores that were about two per cent nickel, and which were impractical as matte smelting ores because of slag volume.

The Japanese problem of high titanium ore, as well as the German deficiency of manganese, were minimized by this furnace. Had their owners been able to continue production, the place of these furnaces would have been increasingly more important.

Tigerschiold reports 30 furnaces in production in 1944 and estimates their capacity as about 1,000,000 tons of ore per year. His figures indicate one plant with ten kilns, each handling 300 tons of ore per day. The reducing fuel, crushed coke (15 per cent moisture, 15 per cent ash), was about 26 per cent of the weight of the ore, the heating fuel was coal and amounted to 5 to 7 per cent of the weight of the ore.

This furnace is particularly adapted to those highly siliceous ores lacking lime for self-fluxing. It is a particularly valuable nickel recovery furnace in war time.

Figure 1 — This chart shows that the ore charged into the open hearth is an important source of iron.



A WORKABLE PROCESS

With increased pig iron usage, it will be recognized that the overlooked pig iron and ore direct reduction process we have is by far the outstanding method of reduction by other than coke. The basic open hearth does not operate well either on all scrap or all pig iron. It does operate very well provided there is a little scrap available, the minimum desired amount being enough to weight down the limestone and ore in the furnace until the molten iron can be added.

An actual heat of steel made with no scrap gives an indication of the real power of the open hearth process to provide for direct reduction. A heat made in Republic Steel Corporation's Cleveland district in 1942 charged 437,530 pounds of hot metal, and also handled 90,910 pounds of Cliff Shaft lump ore, and 37,000 pounds of 66.5 per cent Fe magnetite sinter. Think the figures over! A single heat reduced 57 tons of ore in 9 hours and 40 minutes! Only the Krupp- Renn furnaces handled more tons per hour and the Krupp product was not steel, not even desirable melting scrap.

The ability of the basic open hearth to use ore is well known, but, like some other obvous facts, is not well enough appreciated to warrant real study to provide the proper ore and facilities for its use. An investigation of Figure 1 shows that it is not unreasonable to predict 300 pounds of Fe, from ore, per net ton of ingots. In Republic's plants we have made, with that amount of ore, enough steel to know what to do when we get the pig iron. We will also find out the cost of oxygen in ore relative to that now moving to our plants in tank cars.

FUTURE SOURCES OF IRON UNITS IN SCRAP

By C. R. HOLTON, Vice President, Bethlehem Steel Company, Bethlehem, Pennsylvania

▲ THE prolonged strain of securing sufficient scrap to keep the steel furnaces going left the industry acutely aware of the seriousness of the scrap problem. The industry's concern has been strengthened, rather than alleviated, because of the lack of any improvement in the scrap situation during the postwar years. Today we all are making every effort to find ways and means whereby we may again return to the happy state where scrap will be available when and as it is needed.

Practically one-half of the materials going into the steel produced in the United States today is scrap, which, to use the War Production Board's definition, "includes all ferrous materials—alloyed or unalloyed, of which iron or steel is the principal component, which are the waste of industrial fabrication or objects that have been discarded on account of obsolescence, failure, or other reasons."

An interesting fact about scrap is that it is the only one among the principal raw materials used in steelmaking over which the larger steel producers do not have some measure of control. The collection, preparation and shipment of scrap are carried out by outsiders who have now become what is known in the industry as "captive." This statement refers only to that part of the scrap generally known as purchased scrap, which is about one-half of the entire scrap tonnage. According to Mr. Barringer, there are about 4500 dealers who ship one or more cars of scrap a month, with about 200,000 people employed in the collecting, sorting, and disposal of the scrap and associated materials.

There are two main classifications of the scrap used in steelmaking, home or revert scrap, and outside or purchased scrap. Home scrap, as the name implies, is produced by the steel industry itself, mainly in the form of crop ends of blooms, slabs, billets, bars and others of the numerous shapes turned out by a steel plant. It is almost always consumed at the point of origin. Purchased scrap is produced wherever steel is used, and is collected, sorted, prepared, and stocked by scrap dealers. It includes industrial or factory scrap, produced in thousands of factories and industrial establishments throughout the country. Other sources of purchased scrap are the railroads, automobile graveyards, farms, public utilities, and petroleum industry, as well as the demolition of old buildings, ships, etc. A typical ratio between the purchased scrap obtained from these different sources is: Industrial scrap, about 40 per cent; railroad scrap, 15 per cent; and the remainder, or dealer's scrap, 45 per cent.

In 1947, with a production of approximately 85,000,000 net tons of ingots and steel castings, and about 13,500,000 net tons of iron castings, the steel and foundry industries consumed roughly 58,470,000 net tons of pig iron and 59,400,000 net tons of scrap, close to a 1:1 ratio. Of the scrap used by the steel and foundry industries, 31,338,000 net tons was home scrap and 28,081,000 net tons purchased scrap, also very near to a 1:1 ratio.

Figure 1 — The charging boxes, feeding the ever-hungry furnaces, are filled with widely varying types and quality of scrap.

The above ratio between home scrap and purchased scrap has really remained fairly constant since 1935, the first year in which the U. S. Bureau of Mines published statistics on these materials.

The importance of an annual consumption of approximately 25,000,000 tons of purchased scrap in the nation's economy can hardly be overestimated. The pro-

duction of a corresponding amount of pig iron would require the mining and transportation of approximately 50,000,000 tons of iron ore, 35,000,000 tons of coal and 10,000,000 tons of limestone. To produce this amount of pig iron would take at least 50 or 60 of our latest-type blast furnaces. Furthermore, while open hearth furnaces may be operated on a 100 per cent pig iron charge, this practice is not desirable from the metallurgist's point of view and would necessitate an appreciable addition to our present open hearth capacity.

Barring major disturbances at home or abroad, the present high rate of industrial activity seems pretty well assured for some time to come. The pent-up need for consumers' goods will require a long time to satisfy and should not be soon curtailed unless some major economic set-back or similar disturbance should occur. We should therefore be prepared for an annual requirement of not less than 25,000,000 tons of purchased scrap.

As pointed out, this country has always been self-supporting as far as scrap is concerned. However, during the period of 1930-40 over 20,000,000 tons of scrap were sent abroad. Add to this the conservative figure of 150,000,000 tons sent abroad in the form of war materials and armaments, and we find that, conservatively speaking, a total of 170,000,000 tons of steel left the country over a period of about 15 years. The larger portion of this is no doubt irretrievably lost and will never come back to these shores in the form of scrap.

In the domestic field, the 3,000,000 ton increase in pig iron capacity to be completed by steel companies during 1948 will help to alleviate the shortage. The amount of industrial scrap available should be in about the same ratio to steel shipments as during the immediate prewar period. There are some factors that may affect this ratio, but their effects will make themselves felt gradually. The proportion of heavy to light steels has changed considerably during the last two or three decades. In the 20's the production of light steels for consumer goods started to increase rapidly. While the ratio between light and heavy steels was 40 to 60 in the late 20's, it is closer to 45 to 55 today, with the upward trend of the light products still continuing. The higher tonnage of light steels, much of which is not recovered as scrap but is permanently lost, is a factor that must be considered.

Another technological advance in the steel industry is the production of steels of greater resistance to corrosion, steels which will have longer life. This will tend to delay the return of a certain tonnage of steel to the scrap heap. Better protective coatings on steel, both metallic coatings and paints, have the same effect. On the other hand, the increasing tempo of modern living tends to hasten obsolescence of materials and equipment, which will have the opposite effect by shortening the life of steel in many services.

Among technological improvements affecting the scrap situation we may also mention the progressive decline in ratio of home scrap to purchased scrap due to better utilization of the ingot, a tendency which continued progress should always maintain. Twenty-five years ago, the amount of home scrap was approximately 29 per cent of the ingot weight. Today it is nearer 25 per cent.

Available scrap from railroads and automobiles may be expected to increase somewhat as new deliveries allow old equipment to be scrapped. Shipwrecking is another source which should yield more scrap this year and possibly for a few more years to come. The great expansion and modernization program mapped out by a number of our larger public utilities also should release at least their normal quota of scrap as soon as the program has reached full stride.

Systematic methods of collecting scrap, with careful segregation into grades, and with extensive facilities for shearing, briquetting, bundling, cleaning and degreasing are essential. Scrap dealers can render most valuable service by keeping up this work and by further improving their yard facilities. While appreciating whatever progress has been made, steel producers are acutely aware of the need for continued vigilance and further efforts to improve scrap preparation.

To sum up: The past year was a very difficult one for the steel mills. Scrap consumption and scrap prices reached all-time highs, and existence was on a hand-to-mouth basis as stocks dwindled down to a few weeks supply. The outlook for the future is closely tied up with the general industrial situation. As long as the industrial activity, and with it our steel operations, is maintained at the present high level, the scrap market is bound to remain tight. Although no immediate relief appears to be in sight, the following steps would do much to ease the situation: (a) vigorous government measures to obtain part of the large surpluses of scrap now in Continental Europe, particularly in Germany, and in the Pacific, including Japanese stocks, and (b) immediate release of some of the large stocks of war materials in this country now held by the War Assets Administration. The potentialities of these sources are sufficiently great to effect a material improvement in domestic scrap supplies.

THE PREPARATION OF IRON ORE FOR BLAST FURNACE AND OPEN HEARTH USE

By ROBERT R. WILLIAMS, JR., Superintendent of Blast Furnaces, Colorado Fuel and Iron Corporation, Pueblo, Colorado.

▲ THE Colorado Fuel and Iron Corporation receives its principal supply of iron ore from two sources, the Sunrise Mine, located in Platte County, Wyoming, about 110 miles north of Cheyenne, and the Iron Mountain Region, some 20 miles southwest of Cedar City, Utah, in the south central part of that state.Due to the geologic structure of both deposits, the ores are quite variable in chemical and physical nature.

Prior to the installation of the ore preparation plant at Pueblo, the lump sizes, excluding the amount required for open hearth ore, were crushed through gyratory type crushers to 3½ in., on a car to car basis. The nut sizes were used direct and some percentage of the fines

as shipped was sintered over two 42 in. Dwight-Lloyd sintering machines, with a capacity limited to about 15,000 tons per month. Except for small stockpiled surpluses, that may have accumulated from time to time, the ores were not brought into a common mingling operation, and were used in the blast furnace bins, practically on a car to car basis. The ores showed wide variations in chemical content, as indicated by carload analyses, accompanied by irregularities in sizing. These variations were thrown directly on the furnaces, and the effects were that many burden changes were required, and the pig iron produced reflected variations that could not be corrected by operative changes.

The results of a study of the conditions that existed in respect to ore handling indicated that more thorough size preparation and bulk blending would materially reduce the variations in the furnace operations. Accordingly, design work was begun in 1941 and construction work was completed in September 1943 on an ore preparation plant, consisting essentially of crushing and screening units, sintering facilities, and blending beds.

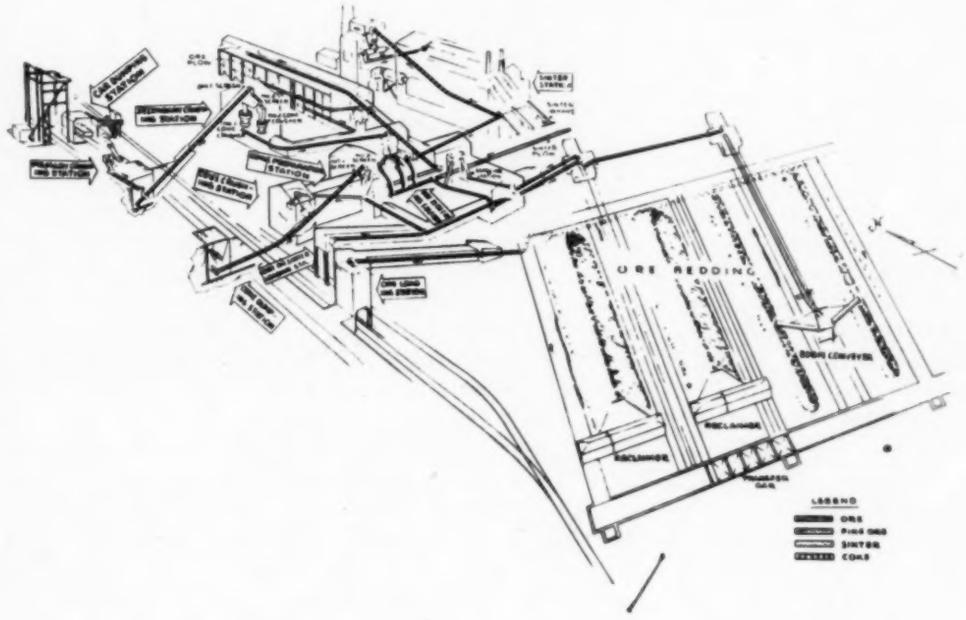


Figure 1 — The ore preparation plant consists essentially of three parts, crushing and screening units, sintering facilities, and blending beds. Conveyors and stackers are used extensively in handling the ore.

To begin the flow of materials through the plant, a 25-ton diesel electric locomotive delivers the ore, in open-top railroad cars, onto the cradle of the track level turnover-type car dumper, which dumps ore into a receiving hopper and returns the car to its upright position. The receiving hopper is so constructed as to deliver the contents of the car onto an apron feeder. The ore is fed over a bar grizzly, the oversize passing into a 60 by 48 in. jaw crusher for primary reduction to about five-inch size. The undersize from the bar grizzly, together with the crushed ore, are collected under the crusher on a second apron feeder and belt conveyed to two 5½ ft secondary crushers preceded by scalping screens. The crushers normally reduce the ore to two inches. The crushing operation is completed and the ore is conveyed to a surge bin, from which it is discharged to three 6 by 8 ft single-deck screens. The screen size normally in service is ¼ x 3 in. so as to remove the undersize ore of minus one-quarter inch for the sintering operation. The oversize ore, which is —2 in. plus ¼ in., is conveyed to the bedding system.

The capacity of the car dumper is approximately 700 net tons per hour. The cycle of operation of the dumper for raising and lowering the car is 1¼ minutes, based on the handling of free-running ore. This allows about five minutes for spotting the car on the dumper cradle, cleaning out any ore lodged in the corners of the car and removing the car after dumping.

The sintering plant proper consists of two Dwight-Lloyd sintering machines each 72 in. wide and 102 ft long. The bin system for the sintering plant is located adjacent and parallel to the sintering plant building, and consists of a long storage bin for ore fines and four bins for prepared coke breeze. The ore bin has a capacity of about 3,000 net tons, and each coke breeze bin will hold about 90 net tons. The bottom of the ore storage bin is constructed with a shelf. Ore is removed from the shelf by means of a rotary plow feeder, mounted on a traveling carriage which moves back and forth in front of the shelf and feeds the material from the shelf in regulated amount of the collecting conveyor, located in front and below the shelf. The collecting conveyor feeds a surge bin located over two table feeds. A table feeder is located directly under each of the coke breeze bins. All tables are individually driven by variable speed motors, controlled from the burner floor. Sinter returns are fed by vibrating feeders directly from return bins at the discharge end of the sintering machines. The sintering mix is conveyed by a common conveyor, located

between the two suction mains, to a hopper over the pug mills. Rotary drum type pug mills five ft in diameter and nine ft in length are in use. Conventional swinging spouts, cutoff plates and burners are used at the feed end of the sintering machines. The machines are equipped with dust hoods over approximately one-half of the bed length. Double vertical-inlet type fans, having a capacity of 137,000 cfm of air at 250 F, are protected by centrifugal dust collectors.

The sinter discharge chute connects to the discharge and castings of the sintering machine to form a housing for the sinter return grizzly, which directs the oversize of finished sinter to the sinter wharf. A sinter crusher or breaker is provided in the lower section of the return grizzly of each machine in order to control the size of the sinter for belt handling. Quenching is accomplished on the wharf and the sinter is fed to a collecting belt in the same manner and by a similar rotary plow as is used at the bottom of the fine ore bin. Two subsequent belts direct the sinter to a loading station, where it is loaded in railroad cars for use at the furnace bins. An alternate system provides for the sinter to be directed with the coarse ore to the beds.

There are four beds on which ore may be blended. The normal practice is to use two beds for stacking while reclaiming from the two remaining beds. Two field belts are required for the stacking operation, and a trailer tripper is permanently engaged in each of these belts. A double wing stacker is coupled to a trailer tripper, and the composite unit is traversed at speeds of about 60 or 110 feet per minute, dependent on the direction of traverse with respect to direction of belt movement. This traverse is back and forth along the beds, with automatic reversal of direction. Thus, many thin layers of ore, one over the other, are placed on the beds to form a pile triangular in cross section, about 50 feet at the base, 18 feet in height and 560 feet in length. Each bed will hold approximately 17,000 net tons of ore when filled.

The reclaiming operation is performed by Robins-Messiter reclaiming machines. Each machine is essentially a traveling bridge, 75 feet center to center of rails, spanning the width of the ore bed and a trench conveyor. A harrow, adjustable for slope and triangular in shape to cover the cross section of the bed, is mounted on the front end of the bridge structure, and is a structural steel grid frame with the vertical and horizontal members spaced about two feet apart. The vertical members are provided with harrow teeth closely spaced. A reciprocating motion is imparted to the harrow by means of a connecting rod and crank; the crank disc being mounted on an extension of the plow conveyor drive shaft to coordinate the functioning of these two units. A reversible plow conveyor is suspended under the forward side of the main bridge structure, and consists of a single strand of steel bar chain to which are attached the plows. The lower strand of the chain operates in a steel trough to carry the dislodged ore to one or the other end of the machine for discharge to a trench conveyor. Subsequently it is carried by two belts to the ore loading station, where it is loaded in railroad cars for the furnace bins.

A self-propelled transfer car, located in a shallow pit at one end of the bedding area, is used to transfer the reclaiming machines from pile to pile and also to transfer the double-wing stacker from one stacking conveyor to another.

The capacity of the system handling the coarse ore to the beds is about 450 net tons per hour. Provision is also made for the handling of 125 net tons per hour of sinter to the beds, should it be desirable to bed this material. The capacity of the system handling ore reclaimed from the beds is 800 net tons per hour. This capacity is reached when two machines are in operation, each machine being capable of reclaiming at the rate of 400 net tons per hour.

The daily analyses and respective tonnages of ores to the beds for the period July 24 to August 9, 1947, during which time 34,927 net tons of ore were stacked in beds numbers 1 and 2, indicate that the iron varies from a low of 40.9 per cent to a high of 64.4 per cent, or 23.5 per cent; the silica from 6.1 per cent to 16.8 per cent, or 10.7 per cent; the alumina from 0.80 per cent to 7.30 per cent, or 6.50 per cent; the lime from 0.40 per cent to 2.60 per cent, or 2.20 per cent; the magnesia from 0.30 per cent to 1.80 per cent, or 1.50 per cent; the phosphorus from 0.055 per cent to 0.274 per cent or 0.219 per cent; the sulphur from nil to 0.25 per cent, or 0.25 per cent.

Effect of Prepared Ores on Blast Furnace Practice

To determine the benefits in blast furnace operation that may be attributed to the use of ores prepared at the bedding and sintering plants, several spot periods of operation were selected. Due to the extenuating circumstances of the time required in the preparation plant's construction, the changes in ore and fuel characteristics, and possibly numerous other conditions, it is difficult to choose periods that would give the similarity of conditions that obtained in comparisons set forth in recent papers. However, the apparent magnitude of the improvements in furnace operations can be indicated by the tabulation of some of the furnace operating data for various periods.

Some of the operating results for the two comparable periods on "E" Furnace are as follows:

Iron production—Improved 197 tons per day or 38.2 per cent.

Coke consumption—Improved 195 lbs. per ton or 9.7 per cent.

Stone consumption—Improved 368 lbs. per ton or 36.3 per cent.

Regularity of product—Improved.

Daily range of silicon in pig iron reduced from 0.57 to 0.25 per cent.

Daily range of sulphur in pig iron reduced from 0.019 to 0.013 per cent.

Operation of furnace—Improved.

Wind blown on furnace increased from an average of 50,213 to 58,475 cu ft per min, with the integrated delivered wind including checks increasing from 36,539 to 44,179 cu ft per min, with an average pressure increase of only 0.4 lbs per sq in. Flue dust loss increased 19 lbs per ton pig iron but still held within reasonable limit of 100 lbs per ton pig. Stock movement was much more regular and flushing and casting operations were greatly improved. Burden changes were reduced from 12 to 9 in metallic mix; from 32 to 23 in stone; from 151 to 12 in extra coke additions.

FACTORS IN SERVICE BEHAVIOR OF SILICA BRICK

By L. A. SMITH, Refractories Engineer, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

▲ SILICA brick are the dominant brick in open hearth furnace roof and port constructions, in coke ovens, glass tanks and in both smelting and refining furnaces in the copper industry. To a lesser extent they are used in welded tube furnaces and soaking pits and in a minor way in other miscellaneous applications.

Recent published figures indicate that on a volume basis, 75 per cent of all refractories brick are fireclay, 20 per cent silica and 5 per cent basic, sillimanite, silicon carbide and other types. A dollar value of $153,000,000 was reported by the Bureau of the Census for 1946 shipments of refractories products, not including grain magnesite. Silica brick accounted for $19,000,000 of this total.

The factors having to do with silica brick performance might be divided into:

1. Factors related to the raw materials, manufacturing processes and other aspects of brick as such.
2. Factors having to do with furnace designs, bricklaying practices, mortars used or other "happenstances" which can and do occur between the brick plant and their actual use.
3. Factors incident to in-service use.

The principal raw material of silica brick is quartzite, which occurs in many parts of this country, as well as in other parts of the world, and generally in locations not too far removed from areas of consumption. Factors of most importance in selection of quartzite materials for good silica brick would include:

1. Silica content should be high—97 per cent or better.
2. Alumina; low as possible—1.00 per cent or under.
3. Alkalis, titania; low as possible. Usually, if alumina is acceptable, alkalis and titania will also be acceptable because their source is principally the aluminous or clay-like materials in or with the stone.
4. When crushed to sand sizes, a goodly portion of the particles or "berries" should be angular in shape rather than rounded.

We are not inclined to stress the bond in silica bricks particularly, except to mention that if impurities like alumina, iron and alkalis are reduced in the interest of better refractoriness, physical strength may be impaired to the point where the lime content will have to be greater than 2 per cent to get bricks that can be handled without losing corners and which won't be abraded too rapidly by sand blast action of high velocity dust-laden gases. The bond in silica brick body is a factor in its service but hardly a critical factor.

Combinations of grain sizes and even grain shape in the brick batch are important factors in the service behavior of silica brick, particularly when we realize that two bricks, equal in practically all respects (fusion, high silica content, low fluxes and even with the same lime bond) will behave quite differently from each other if the quartz particles of the one are rounded, while those of the other are predominantly angular or splintered. The latter brick will spall more easily, although in most usages that characteristic can be controlled satisfactorily. However, the brick made of rounded grains won't carry the hot loading the other brick will. This rules it out for most silica brick applications, and certainly for use in open hearth roofs.

A very definite factor in service behavior of silica brick has to do with how well they have been burned. Most brick shrink in burning, but silica brick get larger, and their growth is appreciable—on the order of 4 per cent to 5 per cent. Later, when they go into service they expand another 1 per cent to 1¼ per cent, which is three times as much as clay brick. Further, since their volume changes take place rather rapidly, the utmost skill and care in the initial heating up of any silica brick structure is called for if strains, cracks, spalls and even disintegration of the brick are to be avoided before they have actually rendered any of the service for which they were bought. If the brick have not been fired so as to develop the volume changes which should have taken place in burning, those changes will tend to occur in the hot end, or face, of the brick in a roof or wall in service. Localized expansions of such magnitude simply mean cracked, broken brick and generally early failure of any structure of which they are a part. A check on how well brick have been burned is their specific gravity which should be around 2.33 to 2.36 for most uses. The gravity of the raw quartzite rock before firing is on the order of 2.65.

A silica roof should be of sufficient initial thickness to stand up without failure or undue distress until other parts of the structure have given their proper quota of service. It may have ribs or it may be plain. It may have drop sections. It can be ringed or bonded. It may be of 12 x 4 x 3 in. or even smaller units, or it may be of shapes 22½ in. long, nine or more inches in width and five or more inches thick. We don't believe that the larger brick for a given roof thickness will last one heat longer than thinner, narrower ones, say three inches thick and six inches wide. Our point is that with an accepted roof thickness, say 12, 13½ or 18 inches and so on, whether or not the roof brick are three, four, or even six inches thick is not a factor in the service life of those roofs.

We are not disposed to argue too much for or against ribs, bonded or ringed construction or other variations of roof design, but each scheme has its place which may be of considerable importance. However, we are not inclined to assign too much weight to these differences as factors in the service behavior of silica brick, although we are personally partial to a few ribs in the middle.

Arch design, expansion provisions, wall ties, camber, adequacy of structural supports and binding are all vital factors in the service life of silica brick. Water or air cooling for vulnerable areas, and incorporation of special refractories in the right spots to get longer life out of the structure as a whole are certainly factors in the service behavior of the silica brick in an open hearth furnace where silica brick predominates.

Mortars used in laying silica brick have been found to have considerable to do with service life, particularly between rings of ringed roofs where the new "high silica" cements have practically eliminated the "wash board" type of erosion occurring both when no mortar was used and when claybonded types were used.

The expansion characteristic of silica brick is on the order of $\frac{3}{16}$ in. per linear foot. The designer can indicate overall expansion on his drawings, and may even break it down into $\frac{1}{2}$ in. or $\frac{3}{4}$ in. gaps every three feet. The bricklayer may follow instructions to the smallest fraction of an inch, but if he carelessly lets spalls or chips lodge in the open joints, or absent-mindedly "forces" brick into too many tight fits instead of cutting so that they fit loosely, the provisions for expansion won't function and the wall will likely buckle, "pinch spall" and fail prematurely.

Then there is the matter of bonding. If the job calls for careful bonding (and most silica jobs do) a good bricklayer won't leave "straight" joints nor will he hide them where no one can see. With the excessive expansion movements of silica construction, usually all work must be well bonded to prevent wall cracks which can slab off rather heavy sections at times.

In building sprung arches, the skewbacks must be set right, which means every brick must be solidly against its support as well as in good alignment with the other skew brick. This isn't always as easy as it looks, particularly when working with an old open hearth, whose structural work may be warped and twisted. If the mason hopes to build a good arch, he must set his skews properly, and that may necessitate more and better cutting than he like to do. If, instead of doing a careful mechanical job, he chooses to use a little extra mud, his arch may weaken just enough to drop a sizable section, seriously impairing roof life.

One more bricklayer item, which we think is of considerable importance, is the keying practice for open hearth roofs. Cutting costs money, but we think it pays to cut and fit plenty of brick at the crown of an arch, so that none will be unduly thin and all will be strong and properly bedded. When keys are driven there should be at least three, one at the crown and others half-way between the skew and the crown on each side. The keys should be tight, but not so tight that they lift the arch off the center. Arches keyed too tight can, and often do, get into "pinch-spalling" trouble.

Then we have the open hearth furnaces which aren't what they ought to be "down-stairs." There may be poor flue design, not enough stack, water or dust accumulations in low places, tight or plugged checkers, or just 75-ton capacity in the cellar, with twice that or more being made "up-stairs." Furnaces with such shortcomings can be found without too much searching. They all "blow" more or less at the doors, and when "blowing" isn't promptly corrected or adjusted, more roof erosion may take place in two days than would have happened in two months of "non-blowing" operation.

With no notion of letting brick or brickmakers off for any shortcomings, we can state that the most important factor in the service behavior of silica roof brick in open hearth furnaces is the way the furnaces are operated. In making this statement we are thinking of heating-up damage, excessive roof temperatures, plugged checkers, reducing atmospheres, dripping water, misdirected burners, flame deflection because of piled up scrap and roof gouging of "tilted-tilters" as some of the more familiar operating factors having to do with service behavior of silica roofs.

It is granted that many legitimate reasons can be cited, and perhaps accepted, in defense of an occasional burn, or a days run with choked checkers, or even an accident of piled-up scrap. However, poor heating-up practices are hardly defensible, and while it is possible to have had "bad brick" in one end of a roof, it isn't probable.

Reducing atmospheres are hard on roofs. The real sting of these reducing atmospheres comes from the fact that the gases traveling through the furnace are laden with iron oxide in both solid and vapor form and as this iron oxide penetrates the pores of the brick, it reacts with silica and other impurities present to form liquid phases, some of which runs and drips, washing with it also silica particles which have not actually been converted to silicates. Fortunately, with neutral to oxidizing atmospheres in most open hearth furnaces most of the time, the higher oxide form of iron is dominant and there isn't too much reaction with silica. However, if conditions change to reducing for even short periods of time, the iron oxide changes and the lower melting silicates form copiously.

BASIC BRICK IN THE OPEN HEARTH FURNACE

By VERNON W. JONES, Superintendent, Open Hearth Department, Armco Steel Corporation, Middletown, Ohio

▲ THE increased use of basic brick in open hearth furnaces has been one of the outstanding refractory developments of the last decade. The wide-spread application of basic materials to open hearth construction is the result of the operators efforts to increase production in the limited space avalable in the older shops. While the rapid increase in the use of basic brick has occurred in the last four years, the present method of application is the result of experience gained since basic brick were first used above the slag line.

With the advent of the sloping backwall, there was a great increase in the use of basic materials. The development of the sloping backwall coincided with the development of chemically bonded magnesite brick and chrome-magnesia brick, both burned and chemically bonded.

The improved chrome-magnesia brick rapidly replaced silica for port corners and made it possible to maintain the desired furnace lines for a longer period of the furnace campaign, contributing to the development of faster melting speeds and increased production. The burned chrome-magnesia brick replaced chrome brick

in initial frontwalls, including arches. These gave exceptionally good service, in many cases lasting for a roof campaign. The unburned chrome-magnesia brick came into general use for hot job frontwalls.

The practical development of the basic roof started as a series of panel tests, and eventually a complete basic main roof was constructed on an otherwise conventional silica furnace at the Johnstown plant of the Bethlehem Steel Company. These tests were conducted between 1940 and 1942 with various basic brick being used. A method of suspension similar to that used successfully in the construction of copper reverberatory furnaces was tried. These tests were not successful chiefly because furnace shutdowns for repairs to frontwalls, backwalls and end sections were detrimental to the basic roof. However, these tests did demonstrate the practicability of the suspended construction and pointed out the necessity of complete basic ends.

Shortly after the conclusion of the Johnstown tests, a roof of similar design was operated for several campaigns, both with and without basic ends, at the Ford Motor Company. The basic roof was discontinued, but the basic ends were retained as economical installations. Almost coincident with the conclusion of the Johnstown tests, early tests on basic ends were started at the Steel Company of Canada in Hamilton, Ontario. In January, 1943, an experimental basic end, which was the forerunner of all the present installations, was built on one end of a 50-ton furnace. Only the port roof and the under cut chill wall on this furnace were built with suspended construction. The balance of the walls were partly solid basic and partly veneered with basic brick. The primary purpose of this experimental installation was to obtain granular, easily removed slag.

The success of this installation led them to convert a 180 ton furnace to a basic end unit in April, 1944. In this furnace, bands of suspended wall tile were altered with conventional masonry sections throughout the uptake walls. Since that time, the bands of suspended brick have been brought together progressively until only one course of brick separates the supported bands. This furnace has demonstrated in service the practicability of the suspended construction of basic ends. The advantages of the suspended type of construction were recognized and the expansion of basic end furnaces has been rapid. At the present time there are 18 furnaces in operation with complete basic ends, two of which have basic main roofs. In addition, there are ten basic ends on order or being installed.

The Armco Steel Corporation is operating eight of the above furnaces, six at Middletown, one at Ashland and one at Houston. The operating experience explained here is that of the Middletown Division, which installed its first basic end furnace in October, 1944.

Cost comparisons between basic end furnaces and conventional silica end furnaces show that the basic end furnace is operated at a lower repair cost per ton. Number 7 furnace (basic ends) was put into operation in October, 1944. The entire expenditure for basic end construction is used in the comparison chart. Number 4 furnace (conventional silica construction) has operated through the same period. These two furnaces were chosen so that the comparison would reflect the increased costs of labor and materials over the period. Figure 1

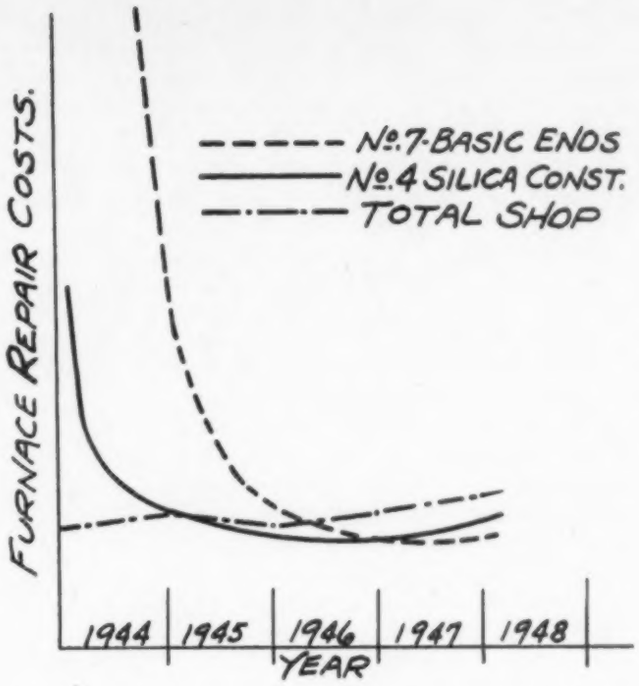


Figure 1 — Relative costs for repairs of basic and silica end furnace for four year period.

covers a period of forty-two months of basic end furnace operations. An accumulative repair cost of the two furnaces is compared to the shop total repair cost for the same period. After 800 heats the basic end furnace was equal in repair cost to the shop average. After 1380 heats the basic end furnace repair cost was the same as the silica end furnace used for comparison purposes. At the present time the basic end furnace repair cost is 28 per cent under the shop average and 11 per cent under the silica end furnace used for the comparison.

The first furnace constructed with basic ends has made 2143 heats to date (3/1/48). The silica end furnace (Number 4 used in the above comparisons) has made 2081 heats in the same period. With all furnaces of basic end construction, we can reasonably expect a production increase of 3 per cent or 27,000 tons per year.

The suspended construction has made it possible to schedule furnace repairs with a much higher degree of accuracy. As mentioned above, the campaign life of a furnace is now regulated by roof life. Except for frontwall repairs we have never had to take a basic end furnace out of operation for anything but a main roof. As the main roof can be inspected daily and repairs planned accordingly, the shop operations are not interrupted by unexpected shutdowns of furnaces caused by the failure of some hidden or inaccessible part of a furnace. Suspended construction has eliminated the danger of failure of furnace sections caused by the difference in expansion rates between old and new silica brickwork. Such failures have happened even when great care was taken in heating the furnace after a repair. The occurrence of such failures resulted in the establishment of arbitrary repair schedules, wherein certain parts of a furnace were replaced at stated intervals, regardless of the condition of the part at the time of the repair. This

practice caused longer repair periods and excessive labor and material costs. Suspended construction permits patching of individual sections, without disturbing any other section. It is now possible to get more life from each individual brick. This does away with the necessity of replacing large areas of very good brickwork due to localized weakening of supporting arches, as happens with conventional construction.

The method of brick suspension used in basic ends permits the use of a single uptake. This increase in uptake area results in a reduction of flue gas velocity, which should reduce the erosion appreciably. We have had one campaign on a furnace with single uptakes and we believe this furnace will require less repair work in the uptakes than a double uptake furnace. The single uptake furnace, which does away with the division arch and burner port cooler, requires less cooling water. In a plant using a recirculating water system, this results in a considerable saving in water and fuel consumption.

The basic end furnace has less out time for repairs due to first, less repairs being necessary and second, the repair being made faster. The out time on the basic end furnaces averaged 154 hours per furnace less than the silica furnaces for the year 1947. This means that fewer bricklayer hours are required, which is an extremely important item at this time in our plant as well as in most steel plants.

Fuel consumption per ton of product is lower in the basic end furnaces than in the conventional silica end furnaces. This is due to a variety of reasons:

1. Repairs are made faster, so less fuel is required to bring furnaces back up to operating temperatures.
2. Less out time for repairs.
3. The campaign length is regulated by roof life. The slag pockets and flues are cleaned out on each repair so that the operating speed of the furnace is the same throughout each campaign.

We use dynamite to remove slag from silica end furnaces. The deposit in the slag pockets of the basic end furnaces is granular and can be removed with a shovel. The deposit in the slag pockets is of such an analysis that it can be used as sinter in the blast furnace or open hearth.

The present basic end construction has made it possible to eliminate all of the silica brick except that used in the main roof and, in our case, that part of the port roof over the aprons. The elimination of this large amount of silica brick reduces the dust hazard considerably, and when basic roofs are found practical, the silicosis problem will disappear so far as the open hearth furnace is concerned. There is also a distinct advantage from the personnel standpoint. The brick masons prefer to work on basic end furnace repairs, probably because of less dust. There is constant pressure from helpers working on silica end furnaces to have their furnaces converted to basic ends. They see that the helpers on the basic end furnaces have more days work each year and earn a higher incentive pay due to less out time for repairs.

The all basic furnace of the Carnegie-Illinois Steel Corporation at South Chicago, is constructed similar to the Steel Company of Canada furnace. This furnace is operating on varied practices such as increased fuel rates, oxygen in combustion, etc., so that furnace life cannot be compared to a furnace operating under normal conditions. No cost data on the operation of this furnace have been published but the performance to date, under extremely severe operating conditions, has demonstrated that the completely basic furnace is practical and economical.

The construction technique of basic ends and roofs has improved rapidly. The first basic ends permitted excessive air infiltration in the early stages of a furnace campaign. This condition has been improved by replacing the combustible expansion spacers with a corrugated metal plate. The outer two corrugations are filled with a suitable packing material, and the inner surface trowelled with chrome cement. This method of construction provides ample room for expansion, and has greatly reduced air infiltration. The early basic port roofs were built with vertically hung tile, the arched contour being obtained by corbelling. The exposed edges of the brick failed in the early stages of the campaign, caused mainly by transverse stresses. The development of the radially suspended roof provides a smooth surface inner roof contour. Service tests indicate an increased life of port roof section.

PROPERTIES AND PERFORMANCE OF OPEN HEARTH BOTTOMS

By HOBART M. KRANER, Ceramic Engineer, Research Department, Bethlehem Steel Company, Bethlehem, Pennsylvania

▲ OPEN hearth furnace bottoms are generally thought of as consisting of magnesite, but in every case other constituents dilute the magnesia content. In open hearth parlance "magnesite" refers to a fired product consisting substantially of magnesia. As magnesia is rather inert in its reactions with open hearth slags, it is considered to be the refractory skeleton of the bottom. Periclase (the mineral name for crystalline MgO) makes a poor "skeleton," as it is a cubic crystal which is hard to bond. It usually appears as rounded grains in the bottom structure, and such rounded grains are not well adapted to providing mechanical or structural strength. Important to the success of a bottom are those more transient components found in the interstices between the cubes or spheres of periclase. These interstitial components are not as resistant to reaction with slag as is magnesia, and as a result the periclase of the bottom is often sloughed away, or is seriously diluted by less desirable materials. The slag environment of the bottom, that is, the character of the slag to which it is exposed, its temperature treatment and the attention given it between heats, determines its performance. Slags are potential solvents for most bottom components, even magnesia being slowly soluble in most of them, depending upon the composition of the slag and its temperature.

DENSITY OF BOTTOMS

While it is possible to grade the grain sizes of magnesite to obtain optimum density, rammed bottoms can be packed to a density of only 145 to 170 pounds per cubic foot. When fired to 2800 F a specimen of such a bottom would have a density of only 172 to 180 pounds per cubic foot. This implies a shrinkage in the hearth which results in open cracks which must be filled up. As their magnesia content is usually between 78 and 80 per cent, their magnesia content per cubic foot amounts to about 134 to 144 pounds. While rammed bottoms have apparently been fairly successful, they are not considered a superior construction for the working face of the hearth by the majority of furnace operators. Such density as is obtained in this way is inferior to that obtained by sintering magnesite-slag mixtures or that available in a magnesite brick.

TABLE I

	Magnesite brick	Sintered bottom magnesite and slag	Rammed bottom as installed	Rammed bottom fired 2800 F
Per cent MgO	86-92	70-74	78-80	78-80
Bulk gravity, lb/cu ft	172	200	145-170	172-180
MgO, lb/cu ft	148-158	140-148	111-136	134-144

On the other hand, magnesite brick with from 86 to 92 per cent MgO have a higher magnesia content than any other magnesitic bottom material available. Its grains have been graded for density, it has been pressed under high pressure, and it has been fired to a high temperature. With a density of 172 pounds per cubic foot its magnesia content amounts to as much as 158 pounds per cubic foot. (See Table I). Those opposing their use as the major portion of the bottom, object principally to the joints between the bricks as a weakness. Flat courses admittedly might present a hazard by floating out, but the true inverted arch magnesite bottoms are sealed by drainage of ferrites into them during the sintering of a reasonable amount (5 to 8 in.) of sintered magnesite surface, and subsequent intercrystalline growth of the periclase in this environment.

THE PERFORMANCE OF OPEN HEARTH BOTTOMS

The performance of open hearth bottoms may be judged by their bad bottom time, by the number of lost heats and by such instances of poor quality of steel as are plainly attributable to bottom irregularities. Generally speaking, bottoms accommodate themselves to the kind of steel being made on them, and the slags which are developed. Another factor to consider is that many serious failures, resulting in delays, are due to shortcomings of personnel in the ordinary daily maintenance. The cost of lost heats is relatively easy to figure and, on the basis of several lost heats through a bottom, decision to install a new one is easy. However, very often, if a sound repair is made, the bottom will produce satisfactorily for many years. In times like the past decade, it has generally proved unwise to install new bottoms, as the figures show that the extra time thus consumed is seldom regained. Certainly, performance should be judged on the basis of a long-range study, rather than upon a few months qualitative observation.

It usually requires ten days to two weeks longer to rebuild a furnace when a new bottom is installed. Twelve days amounts to 288 hours loss in production time. Most new bottoms return to average bad bottom time in two years. Assuming a furnace would operate 90 per cent of the time, two operating years would be 15,768 hours; 288 hours (12 days) is 1.83 per cent of the total time and is the time which would have to be saved in order to break even. Many shops are operating on a 24-hour per furnace per month bad bottom time. This is approximately 3 per cent of the operating hours. A furnace would have to be operating with a 4 per cent or more bad bottom time in order to justify 10 to 14 days idleness, as the time would not be regained unless the best possible bottom is installed. Even a new bottom would probably not stay below 50 per cent of the shop average during the first year, and would be up to 75 per cent of shop average during the second year. It would have reached shop average during the third year, as this seems to be the pattern of most new bottom performances. Then the saving over the old bottom which was operated at 4 per cent bad bottom time would amount to 2½ per cent during the first year and 1¾ per cent during the second year. Assuming 90 per cent operating time, this would amount to a saving of 197 hours the first year and 98.5 hours the second year, or a total of 295.5 hours for the two years. In other words, it would take almost the entire two years to regain the time lost in installing the new bottom. If this furnace had continued to operate at 1 per cent above shop average for bad bottom time its loss in operating time above shop average would have been only 79 hours per year.

In periods of peak production, when tonnage is required for the immediate future, it would seem that the loss of 79 hours per year is a safer gamble than risking 288 hours of furnace time, hoping for either the superior bottom, which will operate with less than shop average bad-bottom time for many years, or perhaps only regain the 288 hours lost time required to install the bottom in two years. Any number of new bottoms, however, show shop average bad-bottom time within the first year.

While composition and physical properties of material are highly important in the development of a good bottom, there are many factors in which personnel is involved in the daily care of a bottom, which may be equally important. Time studies, comparing practices between open-hearth shops, have indicated widely different ideas regarding patching, or perhaps they reveal, in some cases at least, a lack of definite opinion of what the practice should be.

Some open hearth operators insist on maintaining furnace temperature between heats. This helps to "set" clinkered dolomite, and calcines the raw dolomite. It drains the slag from the banks and bottoms and prepares the way for the sintering of a bottom of higher refractoriness. Other operators chill their furnaces by cutting off all fuel between heats for as much as 25 minutes. This allows the slag to solidify in place, prevents setting the clinker, and very little calcination of the raw dolo-

mite can take place. To the ceramic technologist this means that the bottom has not been prepared for the refractory, and the refractory itself will have had no preparation for service by the time charging begins. Slag is not a refractory and too often it is allowed to be covered with refractory only to be released at some inopportune time later on.

While the use of aluminum may be expeditious to assist in draining bottoms, it is not to be recommended due to the effect of aluminum oxide in forming slags of low fusion points which, unless drained, do harm to the bottom.

CONTINUOUS COATING

By F. M. MORROW, Superintendent of Galvanizing, Armco Steel Corporation, Middletown, Ohio, and K. OGANOWSKI, Associate Director, Research, Armco Steel Corporation, Middletown, Ohio

▲ IN general, there are two types of coated products sold; first, the heavy gage, hand dipped items such as various containers that are usually fabricated from material direct from the hot reduction mill, then pickled and coated after fabrication. Second, the lighter gage flat rolled steels are sold, where the thickness is below the limit possible on the hot strip mill, and where surface and workability are also essential. This paper discusses the processes involved in the second case, where the product is coated in either coil or sheet form by the hot dip method, and sold to fabricators in this form. Other processes such as cladding, electroplating, and spraying are excluded.

Customary practice in the production of the lighter gages of sheets or strip is to pickle the hot rolled strip, cold reduce it by 30 per cent or more, clean off the mill oils, anneal, and then temper roll. When these operations have been performed, the strip has been reduced to the specified thickness, provided with the desired ductility for a designated purpose, and the surface has been adequately cleaned.

Quality of the zinc coatings has become increasingly important over the past years. The processing developments mentioned before produce a strip with progressively improved drawing qualities that performs satisfactorily under more and more severe drawing and forming operations. The galvanizer must produce a zinc coating with suitable adherence, which means that it must not peel or flake off during fabrication and expose areas of the base metal.

A continuously coated sheet will greatly reduce peeling in fabrication and improve the protection because the coating is more evenly distributed over the entire surface, with no increase in zinc consumption.

It would seem logical to assume that a continuous coating operation would increase the rate of production over sheet coating by eliminating the spaces between sheets. This has been experienced on a converted sheet unit where speed, gage, and size are comparable to those of a sheet unit. Additional speeds call for the elimination of some of the limiting factors such as heat input and fluxing capacity.

Normal heat losses such as radiation from the refractory pot setting, radiation from the top of the bath, the heating of the strip, and the cold zinc being added, are factors to be considered in determining the production capacity of such a unit.

The usual practice in pot setting construction is to design the furnace so as to transfer the major portion of the heat to the metal at the intake end of the kettle. The normal requirement is approximately 100,000 Btu per hour per square foot of heated kettle surface. If this figure is exceeded, considerable difficulty may be encountered in low kettle life and excessive furnace repairs.

Coating equipment manufacturers and steel plant engineers have suggested many variations such as preheating and prefluxing the strip. These are all worthy of consideration where the advantages of continuous coating are desired. They are particularly advantageous where a sheet coating unit is to be converted, and the capital expenditure must be limited. The rate of production, however, is largely dependent on the amount of equipment provided to achieve uninterrupted operation.

A pay-off arrangement and a shearing device are the minimum requirements for converting a sheet unit to a continuous operation. Delay time, charging coils and feeding them individually through the unit can be partly overcome by installation of the necessary equipment to join the ends of the coils together. Complete elimination of these delays requires the installation of a looping arrangement of sufficient length to allow for the continuous flow of material through the coating unit while the joining and take off operations are being performed. The shearing arrangement must be designed to operate at a speed somewhat faster than the other equipment in order to take up the over-run in the looping system.

A reduction in operating cost usually accompanies such an installation in that operations are either eliminated or combined. In continuous coating of bright annealed galvanized material, acid pickling may be eliminated. In addition, the fuel cost is somewhat lower on a coil line due to the continuous flow of material, which eliminates the on-off condition where the refractory setting is overheated during down periods and lags in supplying heat at the start-up. Improved uniformity of the coating and the elimination of heavy list ends effects a considerable saving in metal cost. In general, it may be stated that cost reduction per ton is in direct relation to the complete elimination of individual operations, or incorporation of individual processing steps into a single production line.

Installation requirements for the successful operation of a continuous line are not too numerous, especially if the processing steps are of a similar nature. In general, there are two basic operating principles to be considered in the operation of such a line; first, the principle of *constant tonnage* per unit of width of the strip. The production rate varies with the width of the strip, but does not vary with the gage, in that the speed of the line is

increased as the gage is decreased, thus letting the production rate remain constant.

This relationship is shown in Table I. For example, approximately nine tons per hour of strip 45 in. wide is produced in 0.020 in. and 0.080 in. thickness; however, speeds of the strip are 100 ft per minute and 25 ft per minute respectively.

TABLE I

Relationship between Tonnage and Thickness, Speed and Width of the Strip

Thickness, in.	Ft/min	Approximate tons/hr for width of the strip		
		30 in.	45 in.	60 in.
0.020	100	6	9	12
0.040	50	6	9	12
0.060	33.3	6	9	12
0.080	25	6	9	12

Second of the operating principles is that of *constant time*, which is typical of all processing operations pertaining to surface treatment, such as pickling, where the speed remains constant and the production rate varies with the thickness and width.

Design and installation incorporating either principle is simple, as in the operation of such a unit. However, if the different steps of processing must conform to different principles of operation and are combined in one line, the design, installation, and operation become quite complicated. In view of the fact that separate processing operations usually require additional personnel, increased handling costs, and greater material inventories, it is a natural tendency to combine as many of the processing steps into a single continuous operation as possible. There are continuous lines in operation that are fed with the product of the cold reduction mill, and deliver a coated product, ready to ship. The strip is cleaned, heat treated, coated, tempered, sheared or coiled, inspected, and stencilled in a single continuous operation. To accomplish all this, it is obvious that the line must be equipped to meet all the requirements of all steps with as few compromises as possible, otherwise uniform quality of the product cannot be maintained.

To summarize, it can be stated that there are, at the present time, three general classifications of continuous coating operations.

First, there is the converted sheet unit, where uncoiling and shearing equipment are the major additional installations. Quality of product from such a line is materially improved, with only slight improvement in the rate of production and the cost of the operation.

Second, there is the converted sheet unit, with decoiling, looping and coiling or shearing equipment added, where the operation is not interrupted between coils, and where the improvement in quality is combined with an increase in the rate of production and reduction in the cost of the operation.

This type of line could be modified by the addition of pickling equipment, which would facilitate the coating of heat treated coils with a scaled or oxidized surface.

Third, there is the continuous line, where the product is processed directly from the cold reduction mill. Here the cleaning, heat treating, coating, tempering, shearing or coiling, inspecting, and stencilling operations are performed in one continuous process. Such a line must be designed for high output to justify the capital expenditure. Still there are limitations to the capacity of such a line. Experience shows that the limiting factor is in the coating operation. Conventional exit rolls do not produce uniform coating distribution at speeds greater than 100 feet per minute.

The early Armco development of zinc coatings that withstand severe forming and drawing operations without flaking or peeling created a new, broad, and distinctive market for such a product, and encouraged the development of special processes for the production of these highly adherent coatings.

In general, it might be said that once a continuous line is installed, and the more or less serious starting difficulties are overcome, there is never a return to individual sheet coating operation. Furthermore, these installations give quality and rates of production in various types of metallic coatings that are unattainable on sheet units.

It is only reasonable to expect that the conversion of the entire industry to continuous coating is only a matter of time, for sheet coating lines are facing exactly the same fate as was faced by the sheet rolling hand mills of a few years ago.

SOME CONSIDERATIONS IN THE USE OF CARBON REFRACTORIES IN BLAST FURNACES

By W. S. DEBENHAM, Research and Technology Division, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania

▲Within four years, blast furnace operators have invested nearly two million dollars in approximately 50 applications of carbon refractories. Among the questions still without final answers are the following: How should carbon be used, and what special installation procedures and precautions are necessary?

The deterioration of regular fireclay hearths is both physical and chemical. Physically, the pattern is generally as follows:

1. Highly fluid superheated iron under pressure enters brick joints.
2. The hearth tile are compressed or shrunk in both horizontal and vertical directions, widening joints and deepening iron penetration.
3. Brick float out or are more readily eroded because of greater surface exposure, and the process continues.

Chemically, hearth block are subjected to slag attack, possible reaction with FeO formed from infiltrating air, and to reduction of silica, the latter reaction bringing about a gradual replacement of refractory by metal.

Any refractory proposed for hearth improvement must excel fireclay brick in high temperature volume stability and in resistance to chemical corrosion. Of

these characteristics, volume stability is of primary importance. Hearth refractories should resist deformation indefinitely under a surface temperature of about 2900 F and a load of 25 to 90 pounds per square inch on a new hearth. The initial cost of an installation of an alumina-silica refractory meeting these requirements is sufficient reason why none have been installed, and ample explanation of the attractiveness of carbon.

While we are still lacking data on some of the high temperature properties of carbon, investigators are in good agreement that carbon will resist deformation under a 25 pound load at temperatures in excess of 3100 F.

As to chemical corrosion by slag, the immunity of carbon in reducing atmospheres requires little comment. There is still some question as to the possible pick-up of carbon by metal. Deterioration by this means would, in all probability, be very slow. On the other hand, it has been shown that while higher alumina refractories might be superior to regular clay brick, no alumina-silica refractories will be immune to slag attack, or could long survive without the aid of water cooling.

As is true with all innovations of new and more costly refractories, economics will determine the extent to which carbon will replace fireclay brick in blast furnace linings. It is obvious from present installations that the greatest possibilities for justification are believed to lie in the hearth. Expectations are high that carbon hearths will so minimize salamander formation and the possibility of breakouts as to eliminate the old problem of whether a furnace should be relined completely or from the mantle up.

It appears that cost may not prove an insurmountable barrier to consideration or carbon as a stack refractory, provided that it can promise an order of superiority comparable to that expected in the hearth, and the relative degree of service improvement with carbon hearths and hard-fired stack linings leaves sufficient incentive for further improvement of stack linings from the standpoint of balance in the overall refractory life of the furnace.

Another important factor in stack linings is resistance to disintegration by carbon monoxide. This has been the prime mover in the present trend to hard burned fireclay brick linings. Carbon brick, being practically free of iron impurities, might be expected to show no disintegration tendencies, and such is the case. It may be expected that carbon has the greater safety factor, as tests indicate that substantially more iron will be required to disrupt a carbon brick than the 1.5-2.0 per cent of iron originally found in a fireclay brick that is prone to disintegrate.

Other considerations in evaluating carbon as a stack refractory are alkali attack and abrasion resistance. As to the former, it can be expected that carbon will be as successful as in resisting slag action in the hearth. Less has been published concerning the relative abrasion resistance of carbon and fireclay refractories, but considering the good correlations that have been found to exist in fireclay refractories between abrasion resistance and strength, it might be expected that the high uniform strength of carbon at all temperatures would make it at least equivalent to fireclay brick.

So far, the bosh has been by-passed in considering the possible extent of carbon usage. Carbon bosh linings are common in German practice, and will be employed in some coming British installations. Thus it would seem that there is no question as to the suitability of carbon in the bosh. The lack of such an installation to date in American practice is probably best explained in a recent paper by the statement that so little difficulty has been found with present American bosh construction that a carbon bosh might introduce construction and operating problems not now existing. Nevertheless, it is general belief in this country that sooner or later carbon bosh installations will be made.

It would appear that, aside from possible economic considerations, there are no valid objections to the use of carbon at any location in the blast furnace. Further, considering all known applications, the entire furnace lining has been, or soon will be, covered by actual installations.

There are three established practices in the application of carbon refractories in the blast furnace:

1. Machined block design. This design has been employed only in Europe. Aside from the important fact that such furnaces performed satisfactorily, no information on the behavior of these hearths is available.

2. Double wall design.—This design, or minor variants of it, is the one most prevalent in this country. Compensation for expansion is provided both by the 2-inch paste joints between blocks and by the three to four inches of compressible, tarred coke breeze between the outer ring of carbon block and the cooling staves.

3. Single wall design.—This design is characterized by a single, heavy inner lining of carbon backed up by fireclay brick. In allowance for expansion, this design is intermediate between the two previously described.

The purely American innovation of the all-carbon tap hole is proving successful, and is eliminating the controversy over the joint use of fireclay and carbon brick in this location. Again, the problem of the height to which carbon must be carried up the side walls for safety has been fairly well solved, and the fact that carbon continues to rise toward the bosh is indicative of the interest now being shown in the economic limit to its use.

CONTINUOUS STRIP PICKLING

By EDWIN D. MARTIN, Research Metallurgist, Inland Steel Company, Chicago, Illinois

▲ THIS paper is restricted to the pickling of mild, plain carbon steel preparatory to cold reduction. Pickling is understood to be the removal of oxide scale, formed during hot rolling, by chemical treatment—generally in sulphuric acid solution.

The technical problems involved in continuous strip pickling of mild, plain carbon steel may be divided into four groups:

1. Mechanical and electrical equipment for continu-

ously pickling strip steel in the form of coils or of continuous strip.

2. Development of a scale which pickles readily.
3. Conditions of acid pickling bath, pre-pickling preparation and rinsing to yield good pickling at high speed.
4. Disposal of waste pickle liquor to the best economic advantage while avoiding stream and lake pollution.

MODERN CONTINUOUS PICKLING

At the present time there are three methods of pickling hot rolled coils. Two of these methods are considered to be continuous in nature, while the third is semi-continuous. The semicontinuous type and the Greer rotary coil type are adapted to the requirements of smaller producers of strip, where the tonnages are not great. When the tonnages of hot mill coils pickled become large, the continuous strip pickler is the conventional type.

In the semi-continuous strip pickler (Figure 1), advantage of the inherent stiffness of flattened hot rolled strip is utilized, and each coil is processed individually by passing through the pickling line.

The rotary coil pickler is designed to pickle continuously the hot rolled strip in loose coils. In this type of pickler the loose coils are rotated on a mandrel in their passage through the pickling and wash tanks. A schematic diagram of this type of unit is given in Figure 2.

The general arrangement of a modern continuous strip pickling line which embodies the mechanical and electrical features developed to date is shown schematically in Figure 3.

The pickling solutions are heated by steam, either injected beneath the surface or circulated in closed coils. In the injection type, which is the most common, condensed steam makes up for losses due to evaporation, drag-out, splash, or spray. In addition, the injected live steam provides agitation which assists in the pickling action. In many installations, the temperature is automatically controlled by motorized or diaphragm-operated valves.

All pickling tanks and the hot water rinse tank are provided with rubber-lined covers and exhaust system. Negative pressure is maintained by rubber-covered exhaust fans connected to the covers by rubber-lined ducts. The fans usually discharge through rubber-lined ducts leading to a scrubber where the acid bearing fumes are washed with water and the acid free air is discharged to the atmosphere. The acidified wash water is discharged through an acid proof sewer. A modern continuous pickling operation has acid resisting equipment for receiving, storing, measuring and delivering concentrated acid (usually 60° Be sulphuric acid) to the pickling tanks. If the spent acid is dumped to sewers, and it is almost universally, acid proof sewers are a bothersome necessity.

Sulphuric acid (H_2SO_4) is commonly used for pickling, due principally to its low cost. The pickling solution varies in strength, ranging from 6 to 26 per cent by volume of 100 per cent H_2SO_4. The solutions are maintained at temperatures ranging from 190-210 F. Higher temperatures are preferable since the pickling rates are greatly increased with increased temperature. While inhibitors have been used in continuous picklers the practice varies with different operators.

As pickling progresses, activity of the bath gradually decreases due to the presence of and increasing quantity of dissolved iron sulphate. As the iron sulphate formed increases, the acid strength decreases. Fresh acid must be added to maintain the desired bath strength. The acid concentration is maintained in this manner until the solution reaches a gravity of 22-25° Be which, in low acid strength pickling, indicates an iron sulphate content of approximately 300 grams per liter. At this point the bath is inactive, and the pickling speed is usually reduced to the base speed of the line, around 60-90 ft per minute. At this point no further acid is added; the acid content is allowed to drop to 2 per cent by volume of 100 per cent H_2SO_4. It is the usual practice to dump the solution at this point, and

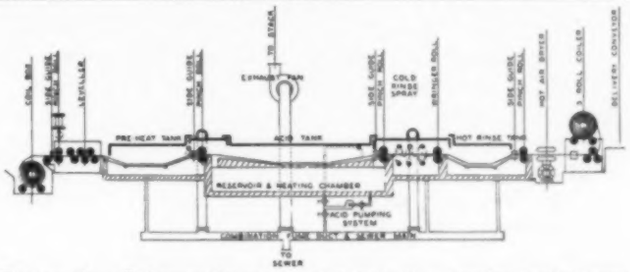


Figure 1 — Schematic arrangement of a semi-continuous pickler.

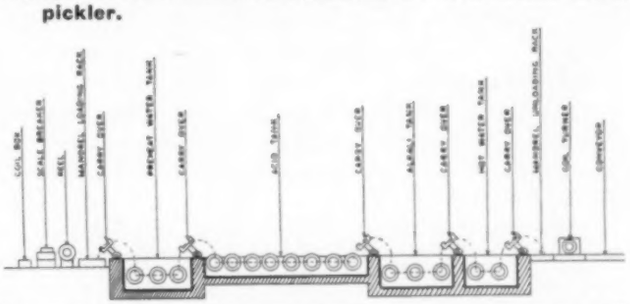


Figure 2 — Schematic arrangement of a continuous coil pickler.

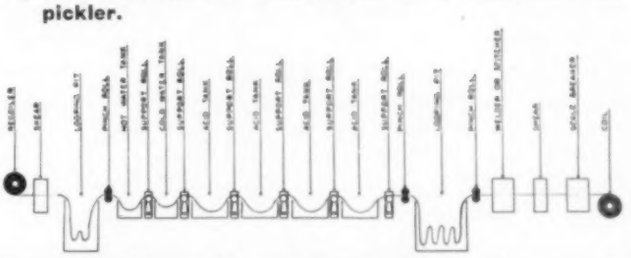


Figure 3 — Schematic arrangement of a continuous strip pickler.

make up a new solution. The spent solutions are normally dumped before the iron sulphate content reaches its saturation point, where it will start to crystallize out in the pickling tanks. If this occurs, it results in hard crystals of iron sulphate heptahydrate ($FeSO_4.7H_2O$) which are difficult to remove. In some instances these crystals have to be broken up by pick and shovel or by light blasting.

At the present time, there are two methods of operating the pickling baths. In the first method the normal four tanks of a line are maintained as individual tanks, and are dumped whenever each becomes inactive. Each such tank usually is dumped at least once in twenty-four hours. The acid concentration in each tank is maintained at approximately the same level. In a late instal-

lation the No. 1 acid tank is placed at a lower elevation than the other three. When any of the last three tanks reach the point at which their pickling action is too slow, the solution is dumped into No. 1 tank, which is used as a sort of rough pickle ahead of the following tanks carrying normal solutions. This method was later modified to a continuous cascade method in which the fresh acid is added to No. 4 tank, and the flow of solution is counter current to the strip travel. The acid concentrations of the first three tanks are determined by the amount of steel pickled and the rate of circulation of the pickle solution. The spent acid is discharged from No. 1 tank. In this type of operation the acid strength decreases from 23-26 per cent by volume of 100 per cent H_2SO_4 in No. 4 tank to 9-11 per cent by volume in No. 1 tank.

The acid consumption per ton of steel pickled depends primarily on the activity of the pickling bath used, whether it is inhibited or not, the time in the pickling tanks, the pickling characteristics of the scale to be removed and on the relationship of surface to weight of the steel strip pickled. Figures obtained from operating data range 35-70 lb of 60° Be sulphuric acid per ton of steel pickled with an average of about 45 lb. The metal loss during pickling likewise depends primarily on the interplay between these factors. In practice, this loss averages about 0.75 per cent of the weight of steel fed to the lines exclusive of cropping.

Speed of pickling may be defined as the maximum line speed allowable for clean pickling. It depends upon the characteristics of the scale, and on the pickling conditions. At the present time, this speed is less than the maximum mechanical speed, which ranged from 100 to 300 feet per minute.

Much has been written on the theory of acid pickling, but many of the theories have been based on insufficient knowledge of the composition and structure of the oxide scale formed on steel by exposure to air at high temperatures. From the equilibrium diagram of the iron-oxygen system, it is possible to infer the probable constitution formed under various conditions. In a section of scale formed above 575 C (1067 F) the first layer next to the iron would consist of "ferrous phase," or wustite, composed of iron and oxygen in the approximate ratio of that formed in the compound, FeO. The layer on top of this layer of "FeO" would be composed of an admixture of FeO and Fe_3O_4, followed by a layer of Fe_3O_4 (magnetite). Next to this layer of Fe_3O_4 would be a layer consisting of Fe_3O_4 and Fe_2O_3 (hematite), which is superimposed on the very top by a layer of Fe_2O_3. Under various conditions some of these layers may be suppressed in the diffusion process. In general, the typical iron oxide scale consists of three phases, namely, the decomposed "ferrous phase" adjacent to the steel base, magnetite (Fe_3O_4), and the outer layer of ferric oxide, Fe_2O_3.

The "Ferrous phase" is considered to be soluble in acid, while magnetite is brittle and difficult to pickle. The Fe_2O_3 ferric oxide is known also to be brittle and relatively insoluble in sulphuric acid baths. The ferrous phase, which is the principal constituent in the iron oxide scale formed at high temperatures, can undergo changes on cooling. As iron oxide scale is cooled from a high temperature, magnetite and iron will separate from the "ferrous phase." As the iron or mild steel material with this scale is being cooled down from a high temperature, the rate of diffusion of oxygen from the air is greater than the rate of diffusion of iron, so that the oxide scale becomes enriched in oxygen, forming Fe_3O_4 and possibly Fe_2O_3 from the "ferrous phase." Also, the rate of cooling of oxide scale through 1067 F affects the transformation of the ferrous phase. Scale rapidly cooled from a temperature above 1067 F is attacked very slowly by a strong hydrochloric acid, while scale cooled at a "normal" rate is attacked by 0.1 per cent hydrochloric acid. In both cases the ferrous phase is preferentially attacked.

THEORIES OF PICKLING ACTION

According to modern theories of pickling, developed on the basis of knowledge of the constitution of oxide scale, the process of pickling is considered to be an electrochemical action, rather than a simple one of acid attack on a homogeneous substance. Many phases of pickling, which in the past were considered to be the simple solution of metal oxide in an acid solution, are now known to be more complex, involving the transfer of electrical charges, the setting up of secondary cells, and the solution of the reaction products of these cells. In general, it is regarded, by those who have investigated this subject, that the oxide becomes cathodic while the steel becomes anodic in acid solutions. The acid penetrating the scale first reacts on the "ferrous phase." The magnetite of this phase is reduced to ferrous oxide, which in turn is dissolved by the acid, liberating hydrogen. As a result of this action the outer scale is loosened and lifted from the surface. This lifted scale, which is slow in dissolving, usually dissolves in the acid after a period of time.

Quantitative pickling experiments on scaled steels have shown that dissolution of scale formed at temperatures above 1112 F followed the above-mentioned mechanism. They also indicated that the time required to remove the scale depended on:

1. Type of scale (especially percentage of the wustite phase in total amount of scale present).
2. Factors affecting the pickling activity of the solution used, namely:
   a. Hydrogen ion concentration.
   b. Viscosity.
   c. Temperature of the bath.
   d. Concentration of iron salts.
   e. Degree of agitation.

Of these, temperatures was found to be the most important.

In order to obtain an understanding of the influence of different bath conditions in pickling with sulphuric acid, an investigation was started at the Inland Steel Company. This work consisted of extensive laboratory studies, some of fundamental nature, and of production tests on one of the continuous pickling lines.

The results obtained on pickling tests of many hundreds of samples, where acidity was varied, indicated that increasing the acid concentration above the 14 per cent (by volume) limit reported in the literature for rapid pickling did not retard the rate of pickling but actually increased it. Instead, a much higher limiting concentration than this was indicated, above which the pickling rate was again reduced. This upper limit of acidity for best pickling was found to be dependent upon the temperature and iron sulphate content. It was

also apparent from this study that there is a certain range of solidity in which the rate of pickling is maximum. This range is independent of the iron sulphate content.

The following facts were noted:

1. Regardless of the oxide conditioning practice, the rate of pickling of the hot mill samples was materially increased in high acid strength solutions (above 16 per cent by volume). The increase in the rates of pickling was apparent in fresh acid solutions as well as those saturated with ferrous sulphate.

2. Entirely unpredictible from data in the literature, certain ranges of acidity and temperature, pickling rate was practically independent of the iron sulphate content—even in saturated solutions. Maximum pickling rate at 190 F was at about 21 per cent by volume of sulphuric acid and at 210 F was at about 18 per cent by volume of acid.

3. Pickling in high acid solutions at 190-210 F, the rates of pickling of the samples from tail ends of dipped coils from the 44 in. hot strip mill approach the rates of pickling of the center samples of these coils. In 5 per cent by volume of acid solutions the difference between the rates of pickling of the tail samples and center samples at these temperatures is very marked.

4. The temperature of pickling has some effect on the rate of pickling. The higher the temperature, the greater the rate of pickling in the range 180 F to 220 F. The increase of pickling rate with increase of temperature in this range was only slight in the higher acid concentrations studied.

Since it has been generally accepted by pickling operators that the presence of iron sulphate in the pickling solution has a retarding effect on the rate of pickling, this factor was studied extensively. From this study, it was indicated that this effect occurred in the low acid ranges and again appeared when the acidity was above approximately 21 per cent by volume at temperatures of 190-210 F.

It was apparent from these studies that pickling activity in high acid strength baths (above 18 per cent by volume) at high temperatures (above 190 F) is different from that obtained at the same temperature, when pickling in baths of low acidity (below 11 per cent by volume).

In view of the favorable results obtained in the Inland laboratory investigations, a plant scale test was conducted on Inland continuous pickling line in which the majority of the hot mill coils from the 76 in. and 44 in. hot strip mills are pickled. This line contained four pickling tanks, each tank 60 ft long. Normally the acidity in each tank is maintained at an acidity of 6.0 to 9.0 per cent by volume of sulphuric acid and the temperature is maintained at 190 F. At the start of the tests, No. I and II tanks, which are the first two acid tanks in the line, were dumped and fresh baths were made up to an acidity of 18 per cent by volume. It was noted that the speed of pickling of the steel being processed was equal to the maximum operating speed of the line. Because of this, it was decided to maintain the other two tanks of the line at the normal strength of 6.0 to 9.0 per cent by volume of sulphuric acid. Thus, the pickling solutions consisted of 18 per cent by volume in tanks I and II and 6.0 to 9.0 per cent in tanks III and IV.

After this test had been conducted for one week, the results appeared so favorable that the operating department requested the test to be continued. The test finally was run for a period of four months in which 60,000 tons of hot mill coils were processed. During this period, the acidity in the first two tanks was maintained at between 14.0 and 20.0 per cent by volume as much as possible. At times, the acidities had to be maintained at low levels due to acid shortages. When the ferrous sulphate content in either No. I or No. II tank rose to 65.0 to 72.0 grams per liter iron content as Fe, the solution was bled to lower the iron sulphate concentration so that no separation of iron sulphate occurred in the tanks. The normal practice was to dump 25 per cent of the solution and then add water and 60° Be acid to bring the bath up to the desired level and acid strength. Tanks No. III and IV were allowed to idle at 6.0 to 9.0 per cent acidity and 190 F. No additions of acid were necessary to maintain these tanks in the operating range. No inhibitor was added to any tank during the test. Throughout this investigation, whenever possible, the speed of the line was increased to the maximum pickling speed, as determined by the inspector from his judgment of the cleanliness of the pickled strip.

Facts noted in this study are as follows:

1. The iron sulphate content does not affect the rate of pickling in baths containing 18 to 22 per cent by volume of sulphuric acid in temperatures of 190 to 210 F. High speeds of pickling were obtained with baths saturated with iron sulphate whereas in low acid baths the operating speed was reduced to base speed. This would be in the range of 65 to 72 grams per liter of ferrous sulphate as Fe. At the top limit of this range (72 grams per liter Fe), ferrous sulphate monohydrate crystallized in the tanks.
2. The use of the scale breaker in high acid baths studied was just as effective as in low acid baths.
3. In the high acidity baths studied, the effect of the character of the scale on the speed of pickling was not as apparent as it was in the low acidity baths.
4. The control of acidity to obtain maximum pickling speed was not critical.
5. The acid consumption per ton of steel pickled, not including the acid dumped, was found to be 32.6 lb of 60° Be H_2SO_4. This only includes the acid loss due to the pickling action, drag-out, and overflow loss to sewer. The acid loss by dumping amounted to 30 lb per ton. Thus the total acid consumption was 72.6 lb per ton.

One of the advantages of a pickling bath which permits a high pickling rate independent of the iron sulphate content is that such a bath may be loaded almost to saturation with ferrous sulphate while pickling at speed. Such a well-loaded solution would be ideal for any system which could regenerate the acid and return it to the pickling tanks for reuse by removing the ferrous sulphate. Such a system of acid regeneration obviates the necessity of dumping baths of high acid content as they approach saturation with iron sulphate. Since it had been observed that it was ferrous sulphate monohydrate which separates from such baths and since a suggestion had been found in the literature of the possibility of an inverse solubility curve for ferrous sulphate at the higher acidities and temperatures, Inland proceeded to investigate the factors involved and finally developed an acid regeneration system of great practical value.

It was evident from experimental work that ferrous sulphate can be removed quantitatively as the monohydrate to a low concentration in a high speed pickling bath containing 16 to 18 per cent by volume and nearly saturated with iron sulphate. If the acidity and temperature of the regenerated solution are adjusted, it may be reused for pickling until again loaded nearly to saturation with iron sulphate.

Further studies yielded facts which permit the following conclusions:

1. The ferrous sulphate monohydrate can be precipitated rapidly in a crystalline form of high settling rate.
2. The high settling rate makes it possible to filter a slurry, whose volume is only a small part of the total volume of the solution from which the salt is precipitated.
3. Filtering can be accomplished in centrifuges or rotary vacuum filters.
4. The salt can be washed with cold water, and the wash water sent to a make-up tank to take the place of part of the water lost in the preceding evaporation step.
5. By counter-current rinsing with hot water at the end of the pickling line with the use of recirculating trough-rinse sprays, the volume of the rinse water can be kept down.
6. Since the monohydrate is readily soluble in hot water, hot rinsing does a quality job.
7. Since only hot water is used in rinsing, the steel does not have to be cooled and again heated to dry as is the case with present practices.
8. The rinse water can be reused in the regeneration plant to remove acid entrained in gases, and then added to the make-up solution for pickling. This avoids pollution and waste of acid and salt.
9. Evaporation can be accomplished cheaply with heated gases obtained by combusting coke oven gas.
10. The solutions are maintained at high temperatures throughout. It is not necessary to refrigerate and again heat the solution to pickling temperatures as required by regenerating systems precipitating the heptahydrate by refrigeration cooling.
11. Since lowering of temperature in pipe lines raises the solubility of the monohydrate so precipitation in pipe lines is automatically avoided if not allowed to drop too far in temperature.
12. The monohydrate salt is free-running when dried and of a fine crystalline nature which permits easy pouring and air conveyance. It is the stable form of iron sulphate at room temperature and will not take on moisture from the air. It remains stable on heating to about 300 C. Ferrous sulphate monohydrate ($FeSO_4.H_2O$) weighs only 62.5 per cent as much as copperas ($FeSo_4.7H_2O$) for the same ferrous sulphate content. It can be transported at lower cost per unit weight of ferrous sulphate and there is less water to drive off in those uses which require roasting.

A recovery or regeneration plant was designed based on calculated optimum conditions of the proposed system. The spent pickling solutions, containing 18.5 per cent (volume) H_2SO_4 and ferrous sulphate equivalent to 66 grams per liter of Fe, are pumped from the final pickling tanks of the three lines through a common surge tank to the evaporator. It is combined with approximately five times its volume of recycle liquor from the crystallizer and introduced through spray nozzles into the stream of hot combustion gases from a Petro-Chem furnace. These hot gases at 2000 F affect the flash evaporation of water from the solution and are cooled to a temperature of 215 F. The recycle liquor acts as a crystal seeding agent for the spent liquor. The concentrated spent liquor is removed from the gases by a centrifugal separator and drains to the crystallized. The gases, after leaving the separator, are washed and cooled by the rinse water from the pickling lines to recover any acid going out with the gases.

The concentrated liquor in the crystallizer is heated to a temperature of 220 F by direct contact with superheated steam generated in the Petro-Chem furnace. Fresh acid (60° Be H_2SO_4) is added to the concentrated liquor in the crystallizer to replace that lost in the pickling operation. This brings the acid concentration in the crystallizer up to about 32.0 per cent by volume. At the elevated temperature and high acid concentration, ferrous sulphate monohydrate crystallizes from the solution. The suspension of salt passes down around a baffle from the feed section of the crystallizer to the main volume of liquor. After being in intimate contact with suspended crystals for two hours, the complete crystallization occurred. After settling has occurred the clear supernatent acid solution of 32 per cent by volume is drawn off and is sent to the dilution tank. A portion of this solution is recycled to the evaporator. The heavy slurry is drawn off the bottom of the crystallizer and fed to the centrifuges. The crystals, after washing, are discharged to an air conveyor which affects the final drying.

The filtrate from the centrifuge is discharged to the dilution tank. The concentrated acid solutions in this tank are diluted to the desired strength by the addition of the wash and rinse waters. The diluted regenerated acid solution containing 23.5 per cent H_2SO_4 and ferrous sulphate equivalent to 14 grams per liter Fe is then pumped back to the pickling lines for reuse. The actual value of the acidity of this return regenerated solution will depend on the quantity of solution withdrawn from each line per unit of time. This quantity is in turn determined by overall economic factors.

The proposed pickling system would consist of the continuous pickling lines with a recovery or regeneration plant. The treated solution from the recovery plant is pumped to the first tank of each pickling line. The flow of the solution is concurrent with the travel of the strip from one tank to another. It is then pumped from the last pickling tank to the regeneration plant. The temperature in No. 1 tank is maintained at 205 F while in the other tanks the temperature is decreased from 200 to 190 F successively so as to raise the solubility limit for ferrous sulphate. There is a decrease in acidity and increase in iron sulphate content in each successive tank. No additions of acid are made to these tanks since the acid added in the recovery plant is equivalent to the acid decrease during pickling. Drag-out loss of the acid is practically eliminated by the use of all rinse water in the recovery system.

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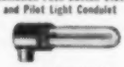
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Type V Vaportight Heavy Duty Lighting Condulet with Shatterproof Glass

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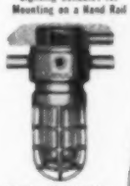
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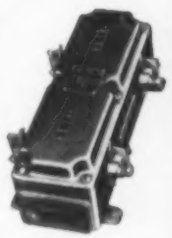
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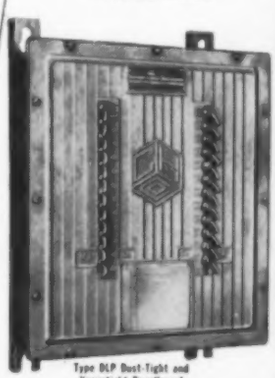
Type DVSP Dust-Tight and Vaportight Panelboard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When single phasing occurs, the current flowing through Fusetrons in the remaining phase increases approximately 100%. This overload on Fusetrons of motor-running protection size opens them and stops the flow of current.

Never before has there been such a dependable way to protect motors against burnout due to single phasing.

Why FUSETRONS Can Give Protection to Any Motor — From 0 to 400 Ampere Size

Fusetrons have a tremendous time-lag. Thus, on normal installations, they can be used in a size near to the actual running current of the motor — without opening on motor-starting current or other harmless overloads.

When so used, Fusetrons protect motors on normal installations from ANY harmless excess of current — caused by such things as being stalled, lack of oil, worn bearings, tight belt, overloading, wrong voltage or single phasing or anything that causes the motor to draw a dangerously excessive current.

Fusetrons Give Many Kinds of Protection Heretofore Not Available

★ Entirely wipe out needless blows caused by motor starting currents or other harmless overloads.

★ Give Thermal Protection to Panelboards and Switches.

★ Operate cooler because of lesser resistance, thus prevent needless blows caused by heating in panels and switches.

★ Permit use of larger motor or adding more motors on circuit WITHOUT installing larger switch or panel.

★ On new installations, PROPER size switches and panels can be used instead of OVERSIZE.

★ Protect small motors against burnout simply and inexpensively.

★ Give DOUBLE protection to large motors.

★ Provide simplest way to stop burnouts from single phasing.

★ Protect coils, transformers and solenoids against burnout.

Send the Coupon Now

GET ALL THE FACTS —

Find out how it will pay you to install Buss Fusetrons throughout your electrical system.

One lost motor — or one needless shut-down — or one destroyed panel, may cost you far more than replacing every fuse with a FUSETRON.

Don't risk such losses — protect yourself by changing over your entire electrical system to FUSETRONS.

Bussmann Mfg. Co., University at Jefferson
St. Louis 7, Mo. (Division McGraw Electric Co.)
Please send me complete facts about BUSS Fusetrons.

Name_____
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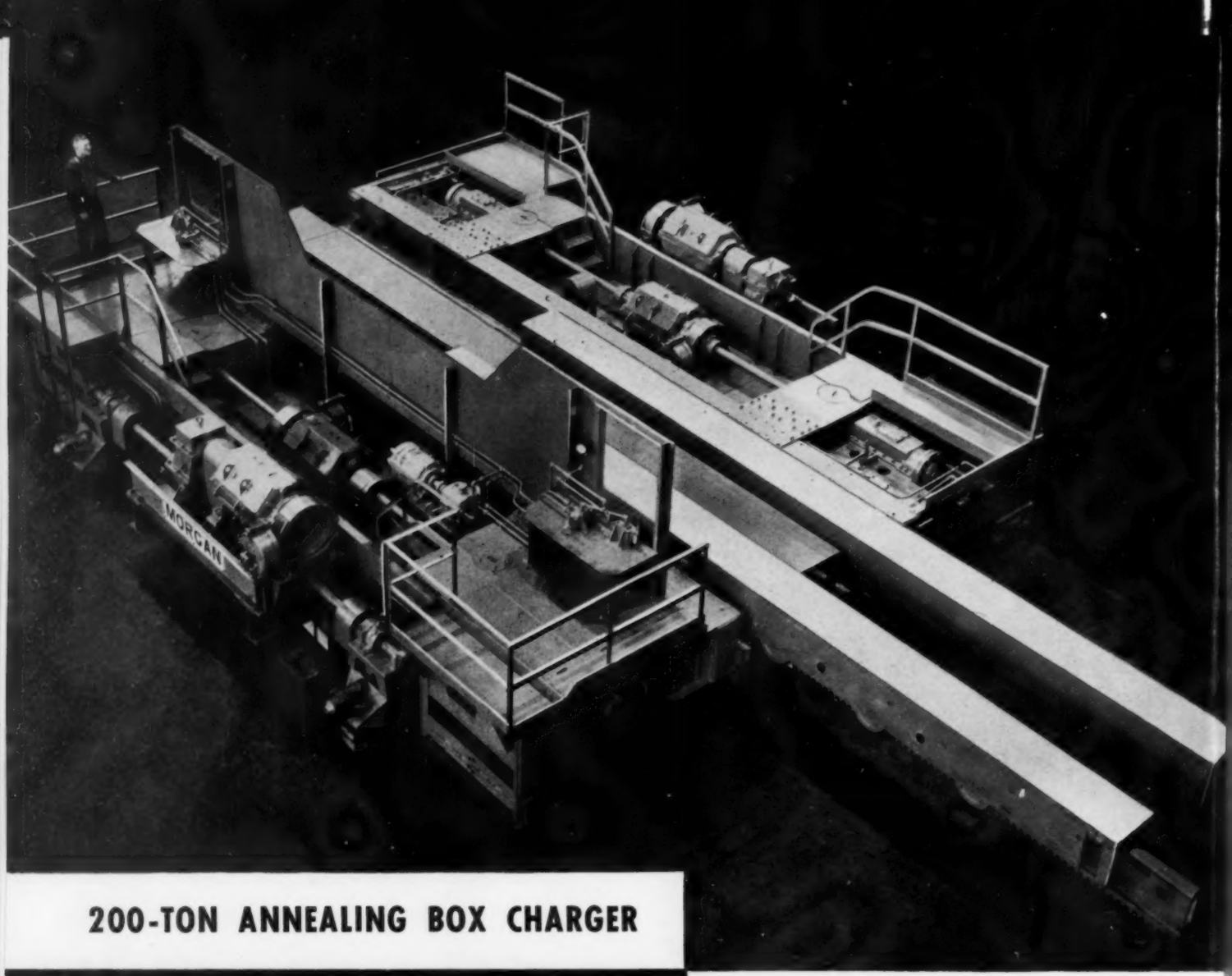

200-TON ANNEALING BOX CHARGER

BUILT BY MORGAN Engineering

Illustrated is a Morgan 200-Ton, 5-motor, 19′-3½″ Span Annealing Box Charger. It consists of a traveling bridge upon which are mounted two rack driven charging trucks operating in unison for raising the annealing boxes and moving them into or out of the furnace or onto the cooling beds. The charging trucks are operated by two motors through four worm units with provision for operating either of the two motors alone.

THE MORGAN ENGINEERING CO.

ALLIANCE, OHIO PITTSBURGH—1420 OLIVER BUILDING

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NEWS SUPPLEMENT AUGUST, 1948

Equipment
Personnel
Literature

Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

J & L DEVELOPS WORLD'S LARGEST OPEN QUARRY MINE FOR MAGNETITE ORE

▲ Rapid exhaustion of iron ore in Minnesota's Mesabi range has led Jones and Laughlin Steel Corporation to develop the world's largest open quarry mine for magnetite iron ore at Star Lake, New York.

Already contributing more than one-eighth of the total iron ore used by the corporation, the expanding Benson Mines are destined to become J & L's important source of ore within the next ten years.

In 1947 over 650,000 gross tons of high grade ore were produced. Output this year is expected to reach 800,000 gross tons and studies are under way to further increase the production.

The future of the Benson Mines is assured as present indications show large reserves of ore.

Meanwhile the high grade Mesabi ore reserves in Minnesota are being depleted at an accelerated rate, and an army of technicians is feverishly seeking new sources and beneficiation methods to assure adequate supplies for the blast furnaces.

The magnetic ores at the Benson Mines differ from the Mesabi ores in several respects. Instead of the rich red "dirt" containing iron found in Mesabi, the lean iron ores at Benson are locked into a very hard rock.

To obtain the ore, this rock must be blasted until the pieces are small enough to be processed through a giant 350-ton gyratory crusher.

Rock from the crusher is still further pulverized by additional crushers, and by rod mills and ball mills in a "concentrator" building.

Once the rock is crushed and ground to a sand, the iron is separated from the waste material by magnetic separators. In these separators, huge magnets draw out the iron, and the waste is carried off to a disposal area.

The fine particles of iron which are drawn off in this manner are impractical for blast furnace operation, because they would be blown out of the furnace in the form of dust. Consequently, the iron particles are fused into large chunks which look like pieces of coke.

The fusion process is known as "sintering" and is effected by mixing the iron ore concentrate with coal dust, and igniting and subjecting it to intense heat.

The finished product — "sintered ore"—is shipped direct to the J & L blast furnaces at Pittsburgh and Aliquippa, Pennsylvania, and Cleveland, Ohio, where it is reduced to iron and refined into steel.

The development of Benson Mines is the result of research begun by J & L geologists nearly ten years ago. Foreseeing the need for additional reserves, they began investigating the possibilities of iron mining in the Adirondack region of northern New York.

Their search led them to an abandoned mine near Star Lake, where the mine pit and plant, stripped and idle

Blasted rock containing iron ore is loaded and carried to the crushing plant at J & L's open quarry mine. This source of ore is destined to become increasingly important to steel production as the high grade reserves of Minnesota's Mesabi range become exhausted.

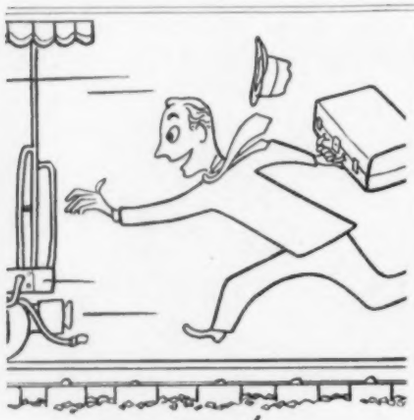
Crushed rock is carried to the separating plant for further processing on long belt conveyors.

for 20 years, were little more than a ruins. The exploration was fruitful.

In 1941, J & L leased the land, and construction of the present plant was begun by the Defense Plant Corporation in the fall of 1942, as part of the World War II production program. This plant was purchased by J & L in the fall of 1946.

Additions to the plant, now under construction at Benson include: 1. Construction of a new pilot "martite" plant for the crushing and concentration of non-magnetic ore which cannot be processed in the magnetite plant. 2. Construction of a new garage and maintenance building to provide the most modern equipment for servicing and repair of the mining equipment.

USE PRODUCT INFORMATION
See Page 17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CLEVELAND PUBLIC AUDITORIUM
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Sept. 28, 29, 30, Oct. 1, 1948

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1948 CADET ENGINEERS STUDY AT BAILEY METER

▲ Bailey Meter Company inaugurated its 1948 cadet engineering class on July 6. A large group of engineers reported, including several from Canada and one from England. The class, one of the largest in Bailey Meter Company's history, is necessitated by the unprecedented demand for the company's products, which are meters and control systems for power and process operations. Twenty-three universities and engineering colleges are represented in the class.

All of the young men in the class are graduate engineers with the exception of three, who have completed their junior year in engineering and will return to school in the fall.

The course consists of lectures on the theory of Bailey Meters and Control Systems as well as factory training in the assembly and calibration of Bailey equipment. Also included is work in the Cleveland main office where the engineers obtain experience in the proper application of Bailey equipment as well as practice in drawing up specifications for those applications.

They also spend a limited amount of time in the research laboratory where they study new equipment and instrument applications being developed by Bailey Meter Company. The course is concluded with a temporary assignment to one of the closer branch offices where the engineers gather actual experience in the installation and field calibration of Bailey meters and control systems.

Upon completion of the training course, these engineers will become part of Bailey Meter Company's staff of over 100 resident engineers in 35 industrial areas throughout the United States and Canada where they will be available to advise and assist power and process engineers in solving their measuring and control problems.

U. S. STEEL OPENS COASTAL WAREHOUSE

▲ The opening of a large modern steel warehouse and facilities in San Francisco, California, has been announced by United States Steel Supply Company, warehousing subsidiary of United States Steel Corporation.

The new warehouse, the company's eleventh, follows the opening of a new one in Los Angeles less than a year ago. The new warehouse will carry complete stocks of steel — carbon, high strength, alloy and stainless— steel products, tools and equipment. The building, a modern steel structure over paved flooring occupies a square block, an area of 260,016 sq ft. It is scientifically planned to speed zoning and loading of steel for shipment.

ORE AND COAL DOCK NEARS COMPLETION

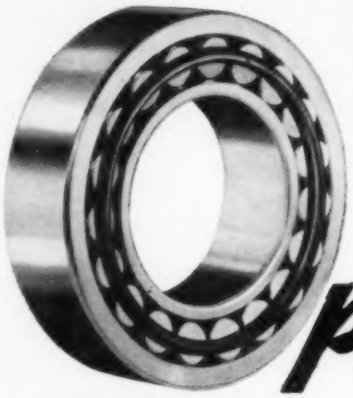
▲ Toledo's mammoth new coal and ore dock, an $18,500,000 joint facility of the Baltimore and Ohio and New York Central Railroads, is in operation and will be completed before the end of the current Great Lakes shipping season, it was announced recently. Already more than 2,000,000 tons of coal have been dumped at the new facility this season.

The new facility, when complete, will have three coal-dumping machines, each capable of unloading the contents of 70-ton coal hopper cars into the holds of lake vessels at a rate of one car a minute, and two unloading machines each capable of removing ore from the ships at the rate of thirty tons a minute.

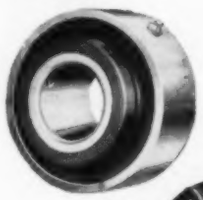
Two Heyl and Patterson coal machines and both of the ore dumpers already have begun operation, while completion of the work is being speeded on the three piers, the yards, the servicing facilities and the third coal dumper.

Located on the lakefront in protected Maumee Bay, the dock facility has a maneuvering basin 2,200 ft long and 600 ft wide immediately adjacent to the lake channel, thus providing

WITH LINK-BELT BALL AND ROLLER BEARINGS *It's*



Operation "O.K."



Users everywhere are putting their big "O.K." on the operation of Link-Belt Ball and Roller Bearings. And they report smoother operation of machines equipped with these dependable, precision-built bearing units.

There's a complete line—mounted and unmounted—from which to choose the bearing to fit your job.

Our experienced engineers will be glad to help solve your bearing problems. Once you install Link-Belt Ball and Roller Bearings, you too will enthusiastically say, "Operation O.K.".

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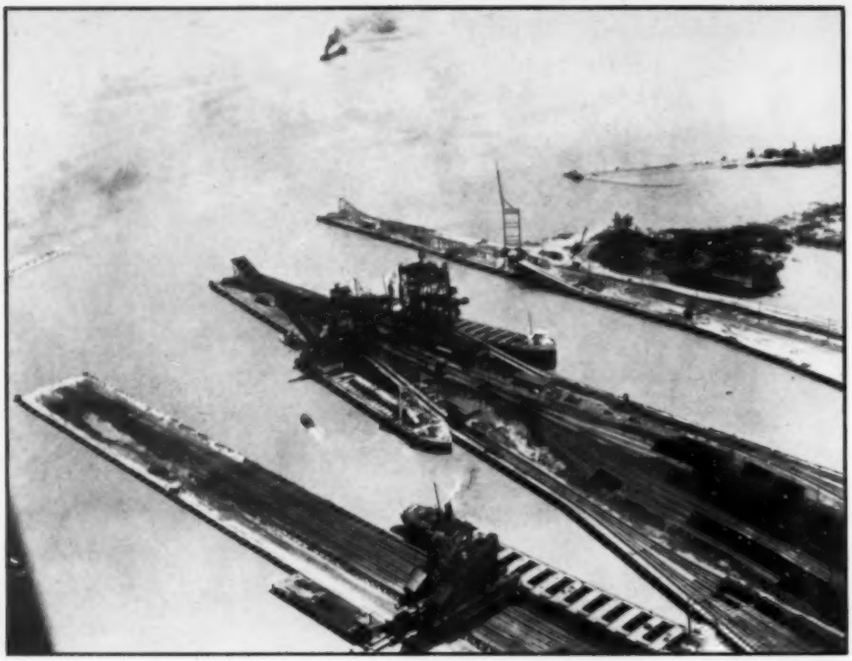
LINK-BELT BALL AND ROLLER BEARINGS



This air view shows the three piers comprising the new coal and ore dock built by the Baltimore and Ohio and New York Central Railroads at Toledo, Ohio, and which began operations this spring. The pier in the foreground contains two unloading machines, each capable of removing thirty tons of ore per minute from the holds of lake vessels. The center pier has two coal-dumping machines, which unload railroad hopper cars of 70-ton capacity at the rate of one per minute into the lake vessels. On the third pier in the background, another coal dumper is being erected.

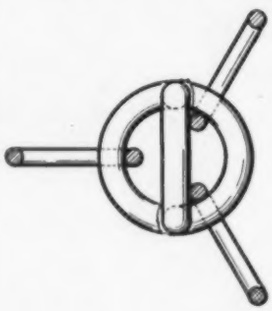
easy entrance for lake boats in all kinds of weather.

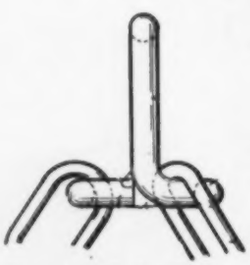
Through this new facility the two eastern trunkline railroads will be able to move as much as twenty million tons of coal and four and one-half million tons of iron ore during each shipping season.

The coal comes from mines in Ohio, Virginia, West Virginia, Kentucky and Tennessee, and is transferred at Toledo from the rail cars to the lake boats, for further movement over water to northwestern lake ports in the United States or Canada. Iron ore, moving in the opposite direction from the Minnesota ranges, is unloaded from the boats at Toledo for shipment by rail to inland steel plants.

Fifty-six miles of track, comprising a principal receiving yard with capacity for 5,400 cars, and nine smaller supporting yards for the individual docks, serve the dock facility. The facility provides for balanced use of rail equipment, as the coal cars, once they are unloaded, can be moved conveniently to the ore dock for reloading and immediate outbound movement. Thus, delays in handling empty cars over longer distances are largely eliminated.

LONG LIVED
Frictionless
Magnet Suspension Chains





Suspension Chains for 55" and 65" Lifting Magnets that eliminate friction, so will last 4 times as long as old-fashioned Suspensions because:

1st: Each leg hangs free on ring and in magnet ears with no twisting or rubbing.

2nd: Suspension is made of high alloy steel — **heat-treated:** periodic annealing not necessary.

3rd: Each 55" Suspension is tested to 85,000 pounds; each 65" Suspension is tested to 115,000 pounds.

Prompt shipment from stock.

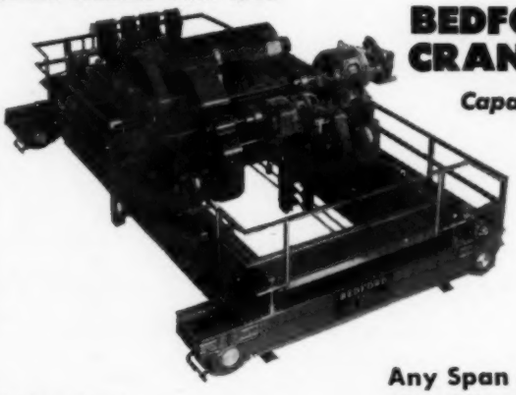
Patent Applied For

DOWNTOWN COMPANY
1836 Euclid Avenue CLEVELAND 15, OHIO

CRANE BUILDERS Since 1903

BEDFORD CRANES

Capacities 5 to 150 Tons



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GANTRY CRANES • STEEL DERRICKS
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Engineers Designers Fabricators
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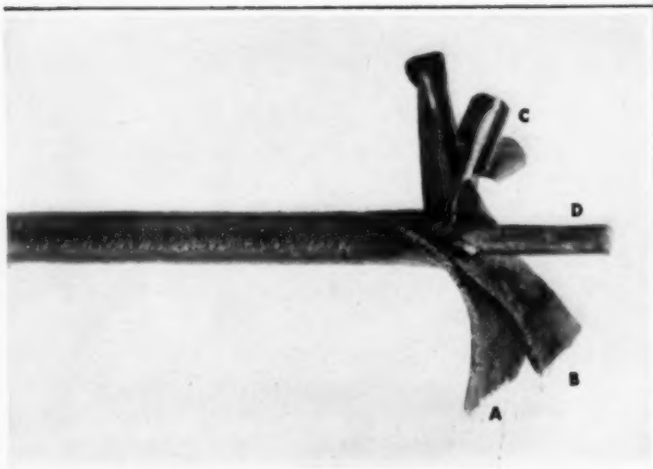
Gray Iron Castings

These Construction Features Give You the Cable

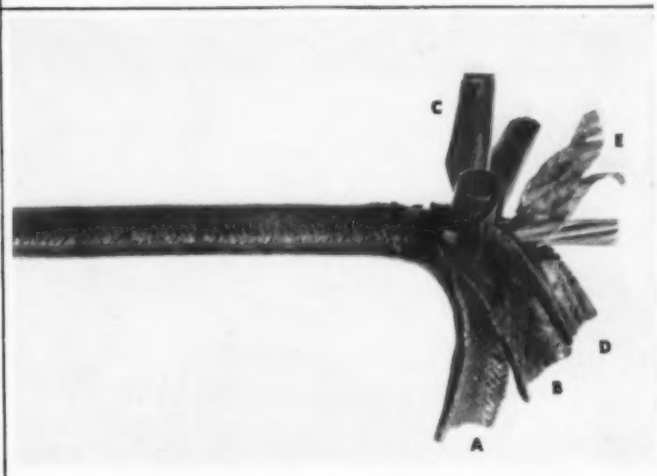
THAT'S PERMANENT

1. Take a sample of Rockbestos A.V.C. Power Cable, illustrated, or similarly insulated Motor Lead Cable, slit open the heavy asbestos braid (a) which is resistant to heat, flame, moisture, oil, and grease, and you'll find beneath a firewall of felted asbestos (b) a permanent heat-barrier against high ambient temperatures.

2. Then cut through this felted asbestos wall (b) peel it back, and see the high-dielectric, moisture resistant varnished cambric tape (c) it protects from heat, flame and oxidation. Notice, too, the uniform coverage of the tapes, helically applied like the felted asbestos to assure perfect and permanent centering of the conductor in the insulation.



3. Now unwind the tapes (c) and underneath you'll see a second wall of impregnated felted asbestos (d) the inner heat-barrier that serves as a baffle against conductor-heating overloads to complete the protection of the varnished cambric.



4. Finally, slit and peel back this felted asbestos wall (d) and beneath is the paper separator (e) which keeps the conductor clean of insulation and makes stripping easy —and that concludes the story of the wire with permanent insulation.

...it all adds up to "the Original Rockbestos A.V.C."

WRITE TODAY — for your copy of the new No. 10-F Catalog, sectioned for easy reference to permanently insulated Lighting Wires, Power and Control Cables; Apparatus Wires and Cables; Switchboard, Appliance, Fixture, Electronic and Magnet Wires.

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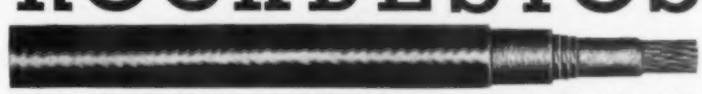

THE WIRE WITH PERMANENT INSULATION

TELESCOPIC TRUCK REACHES TEN FEET

▲ A new 120-inch telescopic Worksaver has just been announced by the materials handling division of Yale and Towne Manufacturing Company. The new tilting fork model—the highest-lifting "walkie" available—has a capacity of 3000 lb and was specially designed to make possible maximum use of available headroom in high-stacking operations. The high reach feature, a full ten feet, can also be used profitably: (1) in reaching such high levels as mezzanines, (2) in servicing overhead cables and ducting, and (3) in loading trucks and rail cars from the ground level.

Such an unusually high reach (120 in.) combined with such a low lowered clearance (83 in.) is accomplished by means of a ram-within-a-ram. When an outer hydraulic piston has fully extended upward, an inner one begins to extend downward, doubling the lift available.

The truck travels at 2 mph under full load, lifts 8 ft per minute with 2500 lb load, and tilts a full 18 degrees in 10 seconds. Total weight of the truck, including a 19-plate battery, is 3,640 lb. Though battery powered in every respect, it is guided by a walking operator.

Worksaver dimensions — 33 in. wide by 64 in. long—make it desirable where aisle space is narrow, when freight cars or street trucks must be entered for loading purposes, and in riding elevators.

The 83-in. telescoped-mast-height permits the truck to operate under low headroom conditions which prohibit use of high-mast trucks. Such conditions exist where there are low doorways, low overhead conduits and service equipment, and where the bodies of public carriers must be entered for loading and unloading.

Applications of the new truck will be found in warehouses, freight depots, food processing plants, paper mills, bottling plants, soap factories, chemical plants—in short over the whole range of industry where overhead space is available for storing materials, where goods must be moved from one location to another, and where high levels must be reached.

Pickling wire in "RODINE" -- inhibited acid means lower pickling costs and more metal saved for drawing.

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RUST PROOFING AND PAINT BONDING
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Pickling Acid Inhibitors Rust Removing Preventing

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RODINE*--saves metal -- controls acid attack -- minimizes over pickling and hydrogen embrittlement -- prolongs life of the acid bath -- saves acid -- holds down fumes -- facilitates scale removal. Just add a little to the sulfuric or muriatic acid bath--For better pickled surfaces--speed--economy--use "RODINE"

Send for full list of ACP metal treating chemicals--of interest to all processors of iron--steel--aluminum and copper products

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PULVERIZED COAL UNIT PASSES INITIAL TESTS

▲ The largest capacity circulating system ever built for firing pulverized coal has passed initial operating tests and goes into regular supplementary service this fall in a midwestern cement plant, Babcock and Wilcox Company, which manufactured and installed the equipment, declared recently.

The system, the first of its kind in the cement industry, was designed as a standby fuel supply for kilns of the Universal Atlas Cement Company at Independence, Kansas. It has been tested during the past few months and is ready for use during the winter when the supply of natural gas is frequently inadequate.

The system has a continuous loop of piping 275 ft long over-all through which the coal and air mixture from a single pulverizing unit circulates continuously to the plant's four rotary kilns. Operation has proved successful in complete coal firing of from one to three kilns at one time and it is possible that further experimentation with a combination of natural gas and pulverized coal in the pipe may make it possible to fire all four kilns simultaneously with a mixture

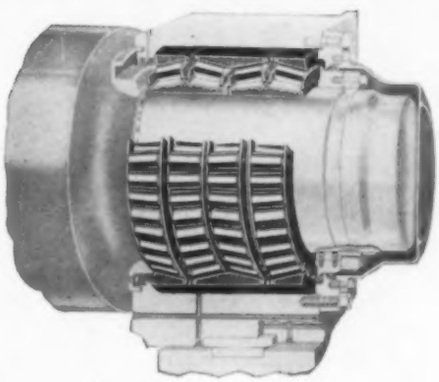
Out of Timken furnaces come the tremendous strength and endurance of TIMKEN® ROLL NECK BEARINGS

Every pound of steel that goes into Timken roll neck bearings is melted in Timken steel furnaces.

Made to a modified Krupp formula developed in our metallurgical laboratories, this fine alloy steel is the ideal material for its job. It is largely responsible for the unequalled performance of Timken bearings in rolling millions of tons of steel at the lowest cost per ton ever recorded.

This steel, plus Timken balanced proportion design, has kept Timken roll neck bearings well ahead of advanced developments in rolling mills themselves. Thus Timken balanced proportion bearings made of Timken special alloy steel show load ratings up to 40% higher than formerly; they also possess 50% to 60% greater neck strength, resulting in greater mill and bearing rigidity and thereby higher rolling precision.

For further information consult your mill builder or our engineers. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address "Timrosco".



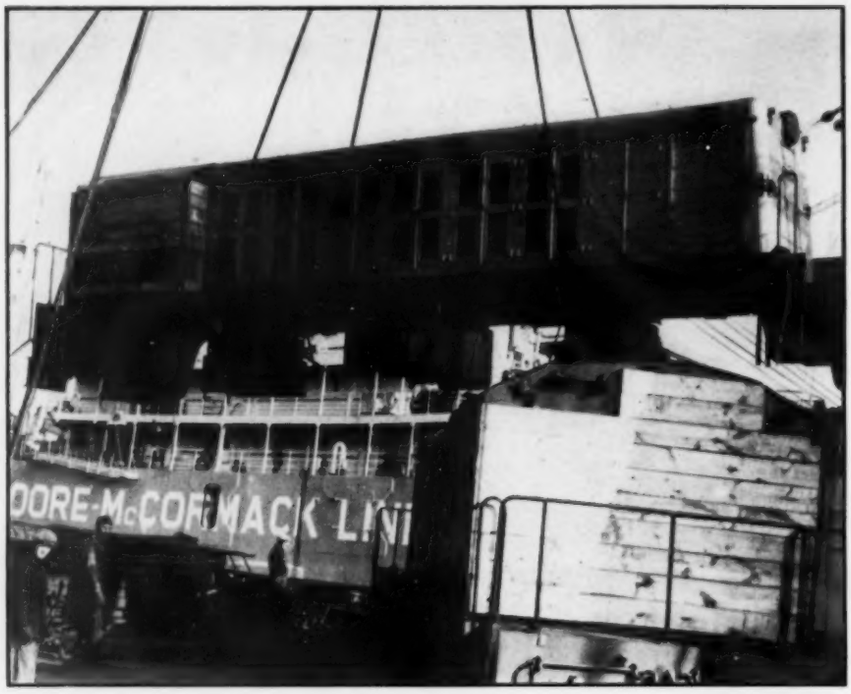
TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

ROLL NECK BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL AND THRUST →◎← LOADS OR ANY COMBINATION →◎←

DIESEL-ELECTRIC LOCOMOTIVES FOR BRAZIL



A 66-ton diesel-electric locomotive being loaded aboard the S. S. Mormacdawn, for shipment to Bahia, Brazil. The locomotive is one of a shipment of nine built for the Ministry of Transport and Public Works of the Brazilian Government by the Whitcomb Locomotive Company.

which is up to 75 per cent pulverized coal.

The coal mill is an E-70 pulverizer, the largest single race pulverizer built by Babcock and Wilcox. It is 12 ft high, with a windbox which has a 9 ft 10 in. outside diameter. Capacity of the mill is rated at 18,250 lb of coal per hour at 50 grindability to 80 per cent minus 200-mesh fineness.

The system was designed for simultaneous firing of two kilns with a peak fuel demand of 15,240 lb of pulverized coal per hour, but with normal kiln output and fuel demands and with average quality and grindability coal, the system meets the requirements of three kilns at once.

The distributing pipeline operates with a surplus of primary air-coal mixture which is recirculated back to the pulverizer exhaust fan. The diameter of the pipeline is progressively smaller from beginning to end to compensate for successive removals of fuel for the kilns of the line. Feeding of coal into the pulverizer and discharge of pulverized coal into the pipeline are controlled automatically. The circulating system which elimi-

NAIL IDENTIFICATION TAGS TO STEEL!

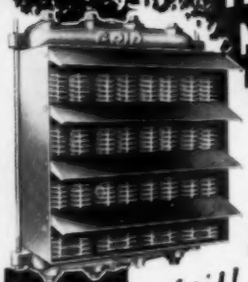
—with the "SAFETY" TAG EMBOSSING and TAGGING OUTFIT

It's hard to believe, but it's true—this Outfit enables you to quickly nail metal identification tags to hot or cold steel ingots, billets, slabs, etc. Tags are embossed, pierced and nailed to steel by swinging hammer in the ordinary manner. Send for complete data today on this remarkable unit.

Write for Bulletin J-547

M.E. CUNNINGHAM CO.
SAFETY STEEL STAMPS
105 East Carson Street • Pittsburgh 19, Pa.

HERE'S EQUIPMENT DESIGNED TO WITHSTAND THOSE CONDITIONS IN STEEL MILLS THAT MAKE SPACE HEATING A HEADACHE!!



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has operated for 17 years without maintenance!

HIGH TEST CAST IRON HEATING SECTIONS

In GRID Unit Heaters there is more "free" area per foot of heating space than in any other . . . no clogging from dust or atmospheric conditions . . . easy to keep clean, GRID Unit Heaters are designed for low outlet temperatures and more air delivery to the floor line — not the ceiling.

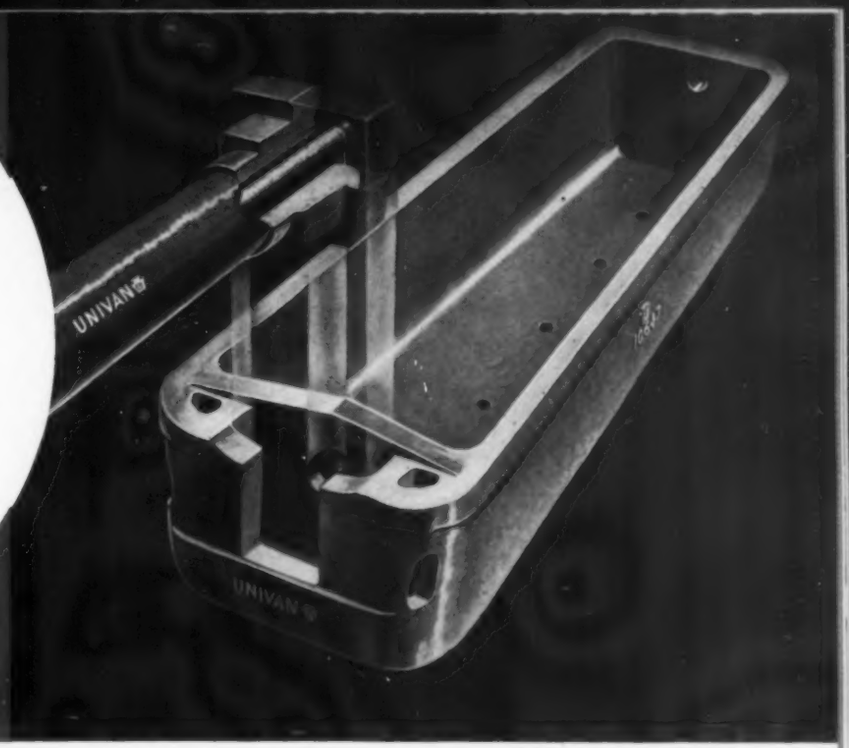
GRID heating sections are one piece construction high test cast iron — the metal for permanency — and more resistant to corrosive gases . . . no rotting away of heating elements, no leakage due to corroded joints or connections . . . no electrolysis because no dissimilar metals are used in GRID construction. No maintenance expense, but years of trouble-free heating service, proven by the 17 years that GRID Unit Heaters have operated successfully in steel mills.

Write for complete details, capacity tables and engineering data.

D. J. MURRAY MANUFACTURING CO.
WAUSAU WISCONSIN

CHARGING BOXES

make mighty expensive SCRAP!



YOU CAN CUT WAY DOWN ON BREAKAGE AND LOSS WITH

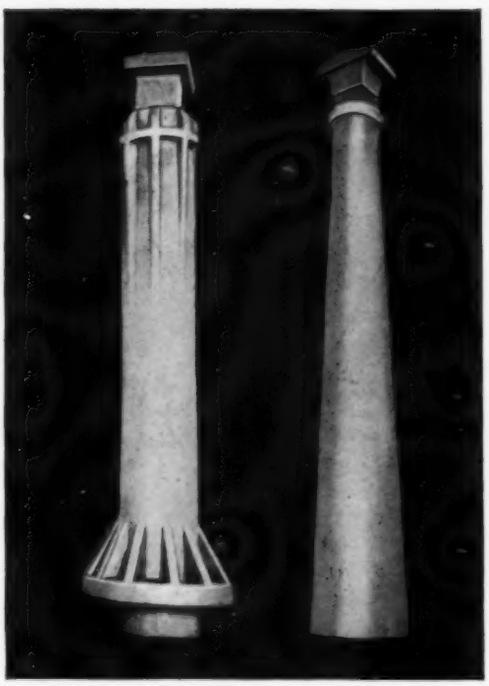
UNION

DOUBLE LIFE HEAD

CHARGING BOXES

Here's why . . . All square corners have been replaced by round ones, insuring a sound casting . . . That specially designed, reinforced head means "double life" without cracking or distortion even with today's higher temperatures . . . Union Boxes are cast from UNIVAN—a special nickel vanadium steel that holds its superior strength under extreme conditions of heat, cold and shock.

Whether you operate with 20, 25, 36 or even 50 cu. ft. capacity charging boxes, we welcome the opportunity to prove that you can do a faster charging job for a longer time at less cost with Union Double Life Head Charging Boxes . . . Your request for further details and prices will receive our immediate attention.



UNION *Alloy Steel* PEELS

Except for the charge itself, no piece of unprotected metal is subjected to greater heat for a longer time than the peel. And, hot or cold, it must withstand severe shock and stresses as well. "Union" has developed for this tough service peels of heat and shock resistant alloys in designs that add months to their useful life . . . Glad to quote from your specifications on either rough or fully machined castings.

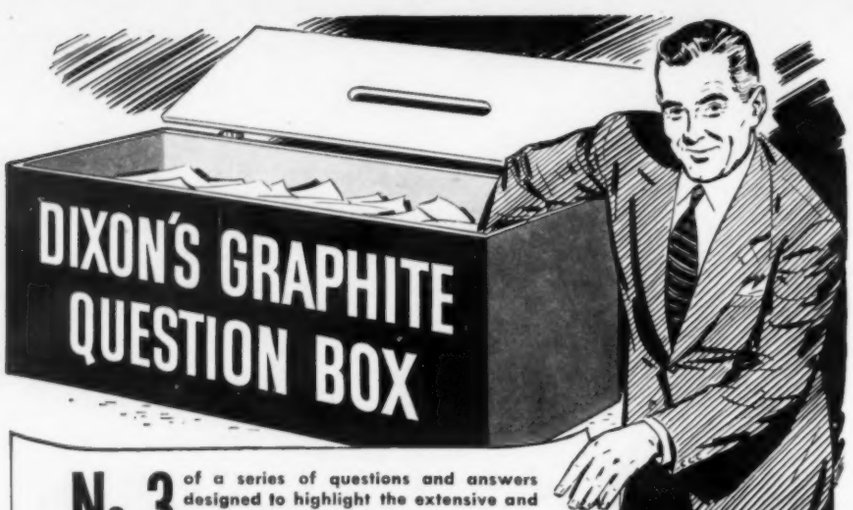
"UNIVAN" Trade Mark Reg. U.S. Pat. Off.

UNION STEEL CASTINGS

DIVISION OF BLAW-KNOX CO., PITTSBURGH, PA.

Cinder Pots • Slag Pots • Coupling Boxes • Spindles • Gears • Bells and Hoppers • Ingot Cars • Charging Cars • Annealing Boxes and Bases

UNION HAS COMPLETE MACHINE SHOP FACILITIES . . . ENABLING THE DELIVERY OF ITS PRODUCTS READY FOR USE



No. 3 of a series of questions and answers designed to highlight the extensive and amazing uses of graphite—from pencils to atomic bombs.

GRAPHITE IN THE ROLLING MILL

QUES. How have many metal-rolling mills reduced power costs up to 25%?

ANS. By using proper types of graphite roll neck greases.

QUES. What accounts for such large savings?

ANS. 1. Graphite, a "solid" lubricant, resists the high bearing pressures which force ordinary lubricants out of the bearing.

2. Graphite fills the irregularities that exist on roll neck and bearing.

3. This graphite film is more readily "wetted" by the oil in the grease.

4. The graphite reduces the internal friction within the grease.

5. By reducing friction, bearing maintenance costs are also reduced.

6. Cooler and better-controlled roll neck temperatures permit closer tolerances, more uniformly finished products.

QUES. Has graphite grease performance been proven by actual tests in rolling mills?

ANS. Definitely yes. Convincing test records and data obtained over the years fully support claims of superiority made for graphite greases.

QUES. Why is graphite or a graphited lubricant considered a "No. 1 must" in the power plant or other plant areas having similar equipment?

ANS. Its resistance to destruction or displacement by heat and pressures, water and solvents assures continuity of power output at minimum operating cost.

A few of thousands of widely used products containing Dixon's Graphites. Those starred are Dixon's products, many of them sold by supply houses everywhere.

★ Lubricating and Penetrating Oil

★ Pipe Joint Compound

★ Graphite (pipe joint) Seal

Now may we receive *your questions* on how graphite can help *you*?

DIXON'S GRAPHITES

Products of
JOSEPH DIXON CRUCIBLE COMPANY
Jersey City 3, N. J. Div 18-Q-8

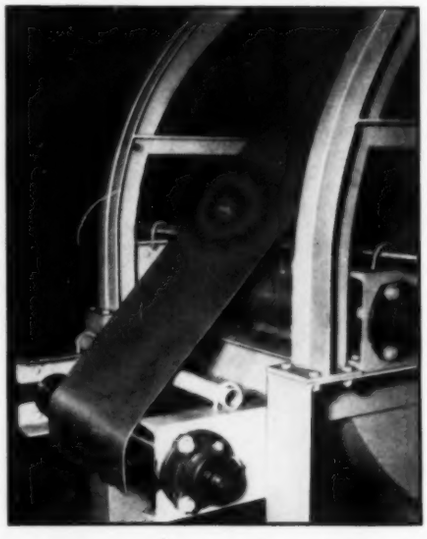
LOOK FOR No. 4
in this series. We will gladly send you reprints of any you may miss

nates storage of pulverized coal is constructed to remove fire hazards and is designed to withstand an explosion pressure of 50 psi. It has a safety factor of four and should an explosion occur the fire is carried on through the burner pipes to the kilns where it is harmless.

VACUUM FILTER AIDS DISPOSAL OF WASTE

▲ Announcing a new, small, continuous "FEinc" vacuum filter as the easiest way to abide by state pollution laws and get rid of the nuisance of waste pickle liquor disposal, Filtration Engineers, Incorporated, culminates several months of joint research with steel mills, neutralization process manufacturers, and others.

Used in conjunction with any waste



This new filter aids the disposal of waste pickle liquors in steel mills.

—acid neutralizing process which results in a suspension of iron oxides and other solids in a neutralized solution, the new continuous filter separates this suspension into easily handled solid cake, and clear filtrate which can be released into streams without danger of acid pollution. The new filter is a special adaptation of the "FEinc" string discharge filter that has long given excellent service with commercial iron oxides and pigments. It is simple, sturdy and has low overall operating cost. Flexibility of design permits the use of slightly more specialized models in a new neutralization process which yields saleable products.

Filtering rate of this small model

AIR EQUIPMENT TO HELP YOUR BUSINESS

READY FOR YOU—

These Latest Answers To Your Air Problems

808 Pages on:

- fans
- air flow
- sound laws
- air properties
- air conditioning
- humidity
- heat
- heat transmission
- drying
- cooling

— and a wealth of other up-to-date air-engineering facts:

Fifth Edition

FAN ENGINEERING

PRICE
$6.00
POST PAID

It's an enlarged, up-to-date 5th edition of the famous handbook edited first in 1914 by Dr. Willis H. Carrier, then Chief Engineer of Buffalo Forge Company. As previously, this 5th edition is edited by Richard D. Madison, who is widely and favorably known in the heating and ventilating field. It covers thoroughly and authoritatively major phases of fan design, air handling and air conditioning. Many topics such as air-flow, sound, dust collection, and material handling have been amplified so that this 5th edition pocket size (4½" x 6¾"), $6.00 per copy, is more than ever a necessity for the man concerned with the movement and distribution of air or gases.

BUFFALO FORGE COMPANY

173 MORTIMER STREET BUFFALO 4, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

Branch Offices in all Principal Cities

FANS by "Buffalo"

EQUIPMENT FOR

- ★ VENTILATING
- ★ HEATING
- ★ COMFORT COOLING
- ★ PROCESS COOLING
- ★ AIR TEMPERING
- ★ AIR WASHING
- ★ EXHAUSTING
- ★ BLOWING
- ★ FORCED DRAFT
- ★ INDUCED DRAFT
- ★ PRESSURE BLOWING
- ★ CLEANING
- ★ DRYING

CUTTING AIR COSTS IN EVERY BRANCH OF INDUSTRY

ranges from 60 to 600 lb of dry solids per hour, depending on nature of waste liquor and type of neutralizer used. This ample filtration rate results in a substantial quantity of work being handled on a small filter. It works equally well on pickle liquor that has been diluted before neutralization and on waste acids that have been used to neutralize waste alkalies before being completely neutralized by the lime or other process. The cake, containing 55 to 75 per cent moisture, can be handled easily by conveyor or truck. The string discharge filter is particularly suitable for recovering cakes that have by-product value.

HOUGHTON OPENS CANADIAN PLANT

▲ E. F. Houghton and Company of Canada, Limited, manufacturer of industrial oils, chemicals and leathers, began operations in its new Toronto plant on July 15. The new plant, an affiliate of E. F. Houghton and Company of Philadelphia, will specialize in the manufacture of metal working products such as carburizers, quenching oils, cutting oils, heat treating salts and drawing compounds. Textile processing oils for wool, cotton and synthetic yarns and surface active agents also will be manufactured, as well as industrial lubricants and mechanical leathers.

BIGGER LOADS...MORE TRIPS
The Blaw-Knox line of Heavy-Duty, Four-Rope Buckets includes many specialized designs for fast rehandling of ore, coal, slag, etc.... Capacities up to 25 tons. From the array of buckets listed and illustrated in Catalog No. 2059 you will find the one that fills your requirements exactly. Send for a copy.
BLAW-KNOX DIVISION
OF BLAW-KNOX COMPANY
2040 Farmers Bank Bldg., Pittsburgh 22, Pa.
BLAW-KNOX BUCKETS

NEW FLYING SHEAR SHOWN TO MILL MEN

▲ Recently at its Youngstown, Ohio plant, the United Engineering and Foundry Company introduced the Talbot type flying sheet shear to a group of engineers, operators and maintenance personnel representing a number of the leading producers of steel, aluminum and brass and copper sheet and strip. A day long demonstration, including actual cutting to accurate lengths as well as free running at a wide range of speeds and miscuts, provided the visitors with an eye-opening performance.

This newest development in a long line of United flying shears, is basically a guillotine shear and comprises pinch rolls, leveller and shear, together with change gear box and miscut gear drives.

The shear differs from predecessor guillotine shears principally in the conception of its knife path motion, but additionally by the inclusion of desirable operational and maintenance features, some of which are possible only as a result of the Talbot motion.

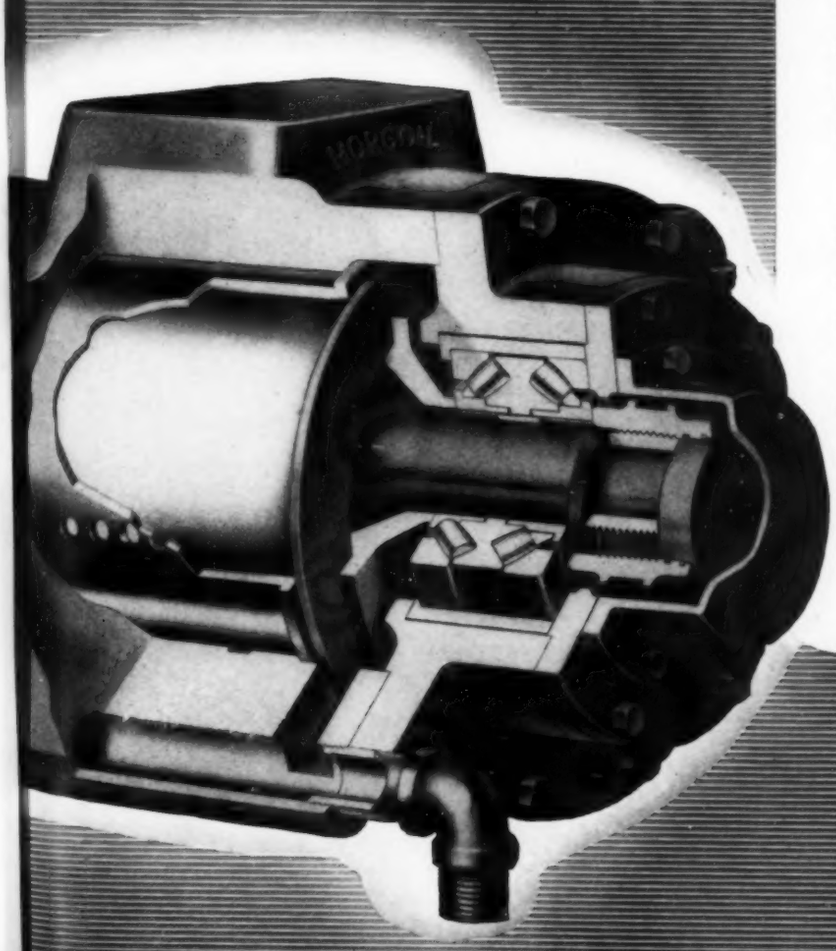
The motion employs the bottom knife pitmans mounted on eccentrics integral with a planet pinion sleeve bushed on main crank eccentric and driven by planet ring gear in timed relationship to top knife main shear frame which is in turn eccentrically mounted on main crank shaft. Variation in number if miscuts is by means of miscut change gears driven from main crank shaft.

Speed synchronizing is by remotely operated adjustable lever on rocker shaft and separate eccentric on main crank shaft.

Notable features offered on the new shear include:

1. On-the-fly adjustment of speed synchronization to permit finger-tip matching of knife speed with strip

You can roll it THICK with MORGOILS



WANT to break down steel slabs or ingots . . . 2½" cold brass? Want a roll neck bearing that will take these tremendous shock loads day after day and come back for more? Want a bearing that is dependable and economical to operate?

. . . Then you want MORGOIL. The only roll neck bearing built by rolling mill specialists and backed by 60 years of rolling mill experience.

MORGAN CONSTRUCTION CO.
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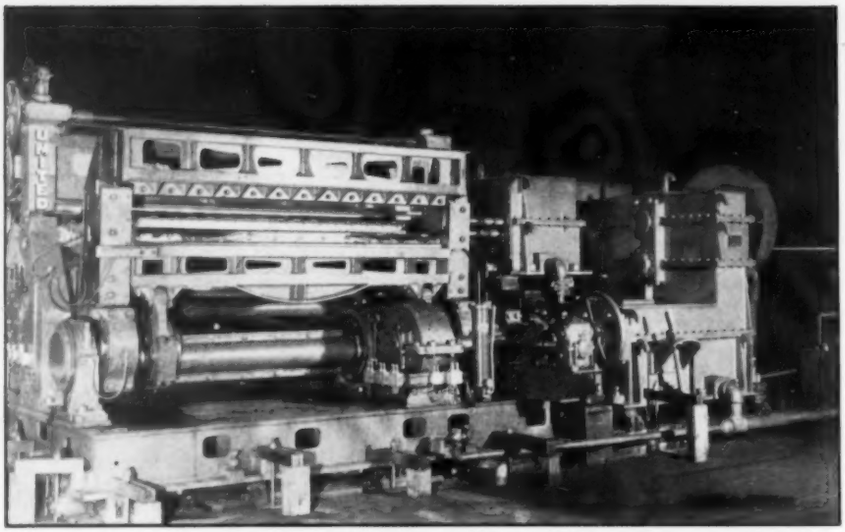


This new flying shear is basically a guillotine shear and comprises pinch rolls, leveller and shear, together with change gear box and miscut gear drives.

feed speed at will, either with shear in motion or at rest.

2. Miscut mechanism of the positively geared type with gear shafter, indicators and auxiliary equipment for changing gears to suit length of cut desired. This shear misses 5 and cuts on 6th revolution and employs four miscut gears to permit cutting lengths varying from 30 in. to 36 ft.

3. Minimum clearance during miscutting between knives for this shear is $1\frac{3}{32}$ in.

4. Shear frame is all welded steel to reduce accelerating loads and hence improve shear life.

All bearings except planet sleeve bushings are anti-friction type.

5. Drive consists of single split change gear box enclosing length measuring change gears, differential, and spiral-bevel gear trains for pinch rolls and leveller rolls, coupled to separate combination double reduction unit with miscut change gear box integral.

6. One differential length scale attached to the P.I.V. speed changer serves all lengths measuring change gear sets, thus simplifying set-up time.

7. The new speed changer replaces conventional Vernier change gear set, thus increasing accuracy in length cut.

8. To assist in making leveller settings without wasting prime material, the shear may be disconnected from leveller with knives open. This operation is simple, quick, and practical.

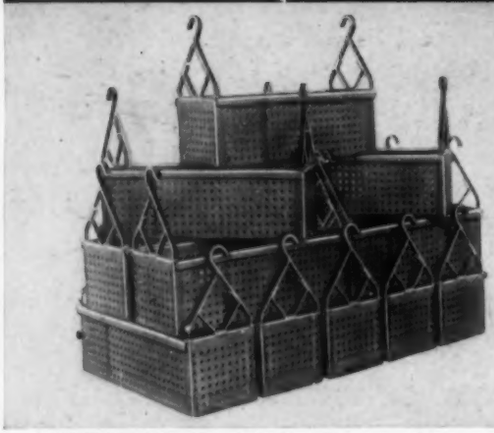
The shear illustrated is designed to cut aluminum alloy from .025 in. to .125 in. thick by 106 in. maximum width into lengths varying from 30 in. to 36 ft at maximum line speed of 300 fpm.

Three smaller shears of this type are now in process of manufacture

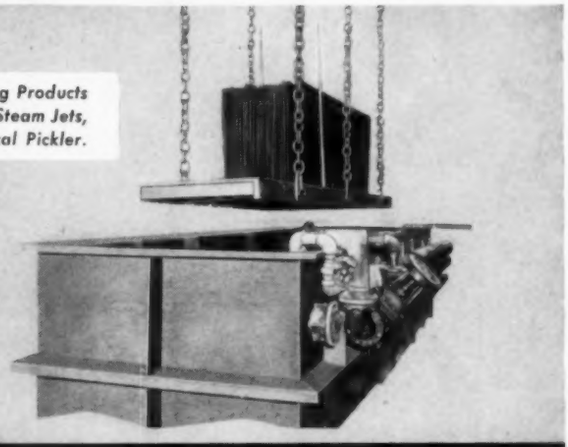
EXTRA PAY LOADS—LONGER SERVICE LIFE

with WELDCO

Pickling Crates and Baskets



Other WELDCO Pickling Products include Chains, Hooks, Steam Jets, and the new Mechanical Pickler.



● WELDCO corrosion-resistant crates and baskets step up your pickling capacity . . . speed up your material handling operations. Made of Monel, Inconel, Stainless Steel, or other alloys, they offer longer service life, high tensile strength, and unusual resistance to corrosion and wear. They're welded in one solid piece to withstand sudden bumps and jars . . . to carry extra pay-loads with greater safety. WELDCO'S trained engineers will be glad to design pickling crates and baskets best suited to your production methods. Call or write today.

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY

3802 OAKWOOD AVENUE

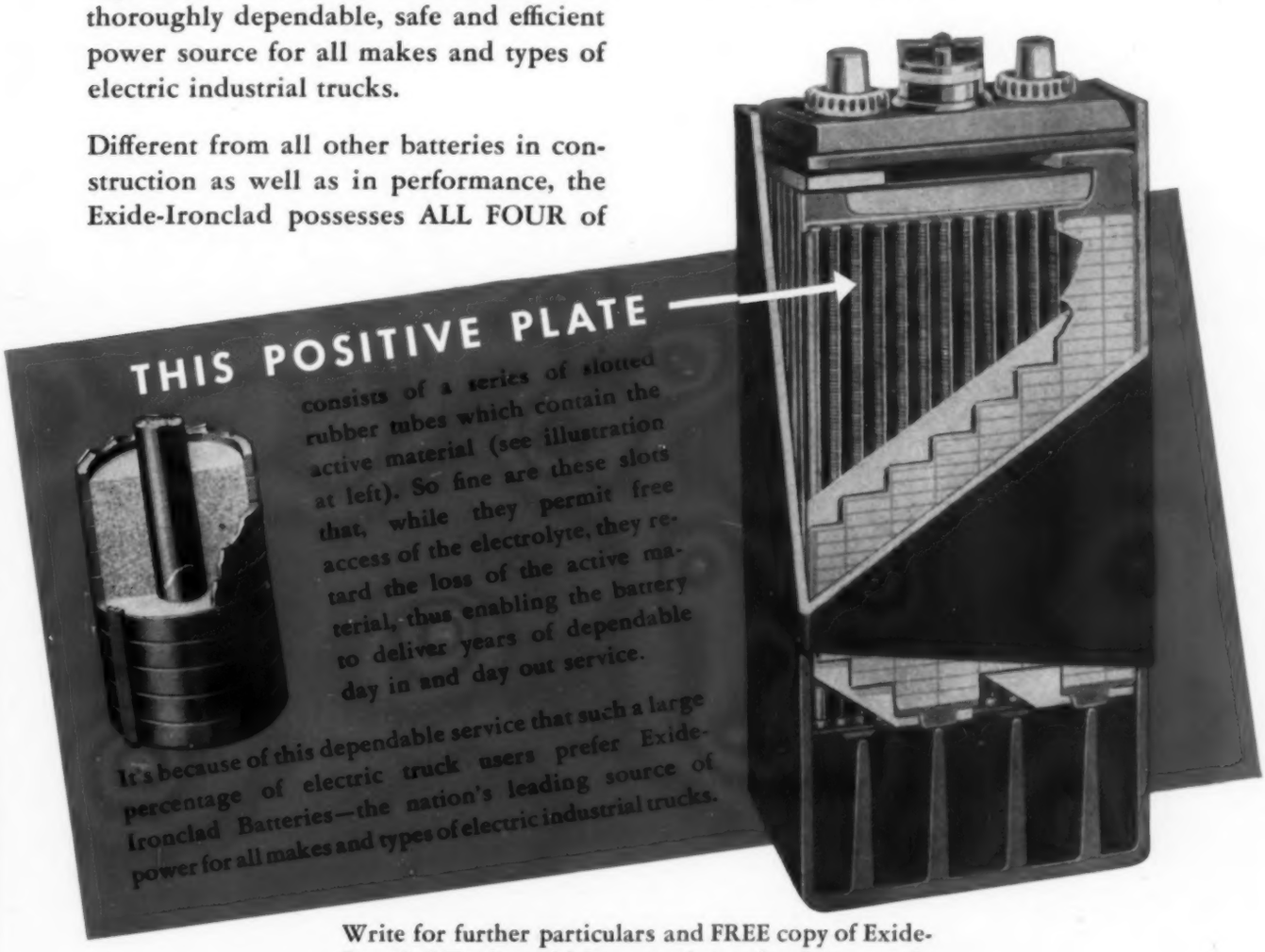
YOUNGSTOWN 9, OHIO

USERS EXPRESS PREFERENCE FOR Exide IRONCLAD BATTERIES

In a recent national survey made by a leading industrial publication, 81.1% of electric industrial truck users expressed a preference for Exide-Ironclad Batteries.

Such overwhelming preference for the Exide-Ironclad Battery is based upon user experience. This unique battery has, during the past 35 years, proved itself to be a thoroughly dependable, safe and efficient power source for all makes and types of electric industrial trucks.

Different from all other batteries in construction as well as in performance, the Exide-Ironclad possesses ALL FOUR of the essential characteristics demanded of a battery for electric industrial truck service—(1) high power ability, (2) high efficiency, (3) great ruggedness, and (4) long life. These characteristics are due to the special construction of the Exide-Ironclad Battery, especially its rugged, tubular positive plate.


THIS POSITIVE PLATE
consists of a series of slotted rubber tubes which contain the active material (see illustration at left). So fine are these slots that, while they permit free access of the electrolyte, they retard the loss of the active material, thus enabling the battery to deliver years of dependable day in and day out service.
It's because of this dependable service that such a large percentage of electric truck users prefer Exide-Ironclad Batteries—the nation's leading source of power for all makes and types of electric industrial trucks.

Write for further particulars and FREE copy of Exide-Ironclad Topics, which covers latest developments in material handling and shows actual case histories.

1888...Dependable Batteries for 60 Years...1948

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia 32 • Exide Batteries of Canada, Limited, Toronto

and will be duplicate in every respect except that they will be upcut action, have improved leveller and pinch roll arrangement and will have capacity to cut 48 in. to 60 in. wide low carbon and stainless steel strip in varying gages up to .090 maximum.

This shear can also be built for usual sheet mill gages and widths to operate at speeds up to 600 to 700 fpm by the addition of specialized balancing equipment which is designed to absorb all reciprocating loads from approximately 200 fpm to top speed and to compensate automatically for all lengths cut.

ELECTRIC METAL MAKERS HOLD 16th MEETING

▲ The 16th annual meeting of the Electric Metal Makers Guild was held in Bethlehem, Pennsylvania, June 16-18, inclusive. On opening day of the meeting, Dr. C. H. Herty, Jr., assistant to the vice president, Bethlehem Steel Company, addressed the joint technical session on the fundamentals in steel melting. The guest speaker on the following day was C. E. Sims, assistant director, Battelle Memorial Institute, whose subject was: "Hydrogen and Nitrogen Contents of Steel." Another highlight of the session was an open forum on the use of oxygen in electric furnace steelmaking. The last day of the meeting was devoted to a visit to the Bethlehem plant of Bethlehem Steel Company.

The following officers were elected for the coming year: president, A. J. Scheid, Jr., Columbia Tool Steel Company, Chicago Heights, Illinois; vice president, F. O. Lemmon, Ohio Steel Foundry Company, Springfield, Ohio; and secretary-treasurer, D. L. Clark, Simonds Saw and Steel Company, Lockport, New York.

CAR-TYPE FURNACE FOR PITTSBURGH FIRM

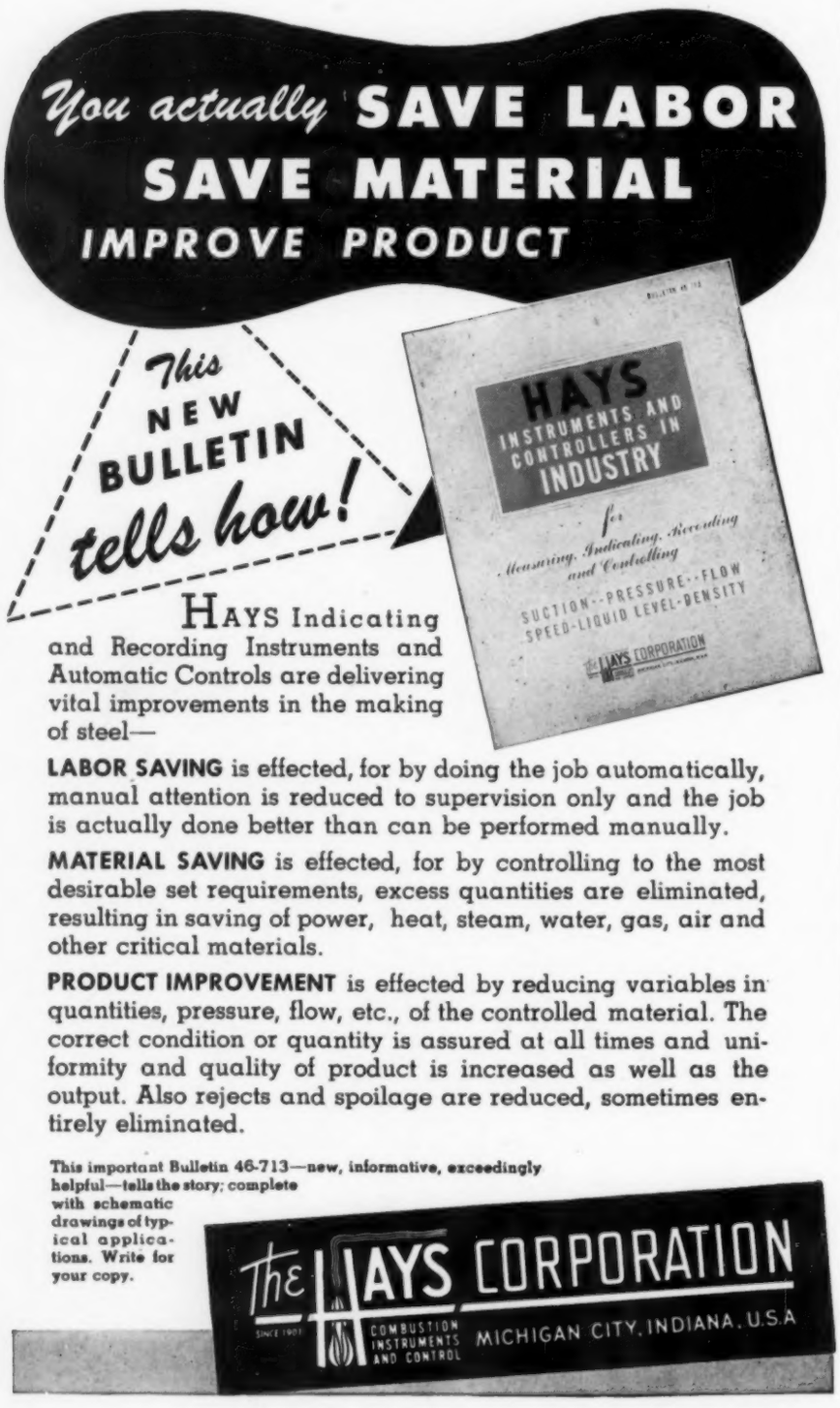
▲ A car-type furnace for heat treatment of complex pipe assemblies is being designed and will be built for Pittsburgh Piping and Equipment Company by Rust Furnace Company.

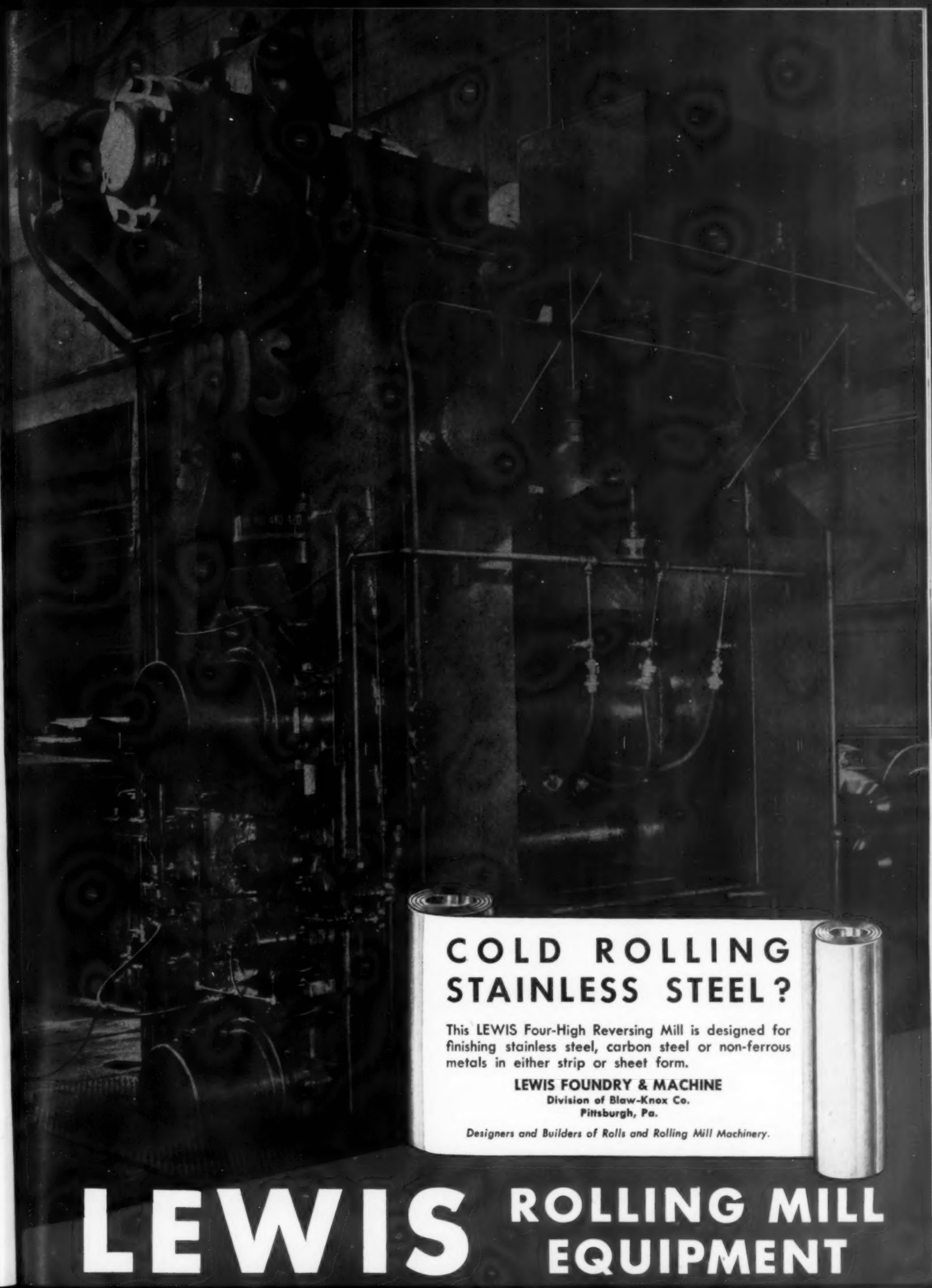
The furnace, now being designed and expected to be in use before the end of the year, will be used for stress-relieving, normalizing and annealing of pipe assemblies, castings and forgings at temperatures from 1100 to 2,000 F.

Inside dimensions of the furnace will be 15 ft wide, 24 ft, 5 in. long and 8 ft from top of car to spring line of roof. It will be equipped to burn either natural gas or oil; and will include three zone automatic temperature control and automatic pressure control equipment.

SOLVENT CAN BE USED AT ROOM TEMPERATURE

▲ A new, cold solvent material, Oakite Composition No. 15 designed to permit fast, thorough removal of paint and similar finishes from metal surfaces, has recently been announced by Oakite Products, Incorporated. The new solvent, the manufacturers report, has demonstrated pronounced effectiveness in removing baking japans, wrinkle finishes, nitrocellulose lacquers, and synthetics such as


You actually SAVE LABOR
SAVE MATERIAL
IMPROVE PRODUCT
This NEW BULLETIN tells how!
HAYS INSTRUMENTS AND CONTROLLERS IN INDUSTRY
for
Measuring, Indicating, Recording and Controlling
SUCTION--PRESSURE--FLOW
SPEED-LIQUID LEVEL-DENSITY
HAYS CORPORATION
HAYS Indicating and Recording Instruments and Automatic Controls are delivering vital improvements in the making of steel—
LABOR SAVING is effected, for by doing the job automatically, manual attention is reduced to supervision only and the job is actually done better than can be performed manually.
MATERIAL SAVING is effected, for by controlling to the most desirable set requirements, excess quantities are eliminated, resulting in saving of power, heat, steam, water, gas, air and other critical materials.
PRODUCT IMPROVEMENT is effected by reducing variables in quantities, pressure, flow, etc., of the controlled material. The correct condition or quantity is assured at all times and uniformity and quality of product is increased as well as the output. Also rejects and spoilage are reduced, sometimes entirely eliminated.
This important Bulletin 46-713—new, informative, exceedingly helpful—tells the story; complete with schematic drawings of typical applications. Write for your copy.
The HAYS CORPORATION
SINCE 1905
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.


COLD ROLLING
STAINLESS STEEL?
This LEWIS Four-High Reversing Mill is designed for finishing stainless steel, carbon steel or non-ferrous metals in either strip or sheet form.
LEWIS FOUNDRY & MACHINE
Division of Blaw-Knox Co.
Pittsburgh, Pa.
Designers and Builders of Rolls and Rolling Mill Machinery.
LEWIS ROLLING MILL EQUIPMENT

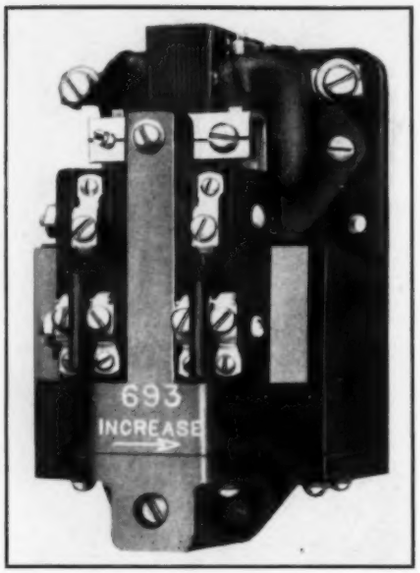
alkyds, phenolics, ureas, vinyls, etc., from such metals as steel, galvanized iron, die castings, aluminum, copper and brass, with no attack on the metal.

Designed for use at room temperature, the composition may be applied by tank immersion method or by swabbing or brushing. This is followed by hot pressure-rinse to remove loosened paint particles. An outstanding use for this material is production stripping of rejects.

A-C PNEUMATIC TIMER HAS SIMPLE ADJUSTMENT

▲ A new a-c pneumatic timer designed for a wide variety of industrial control timing needs such as machine tools, conveyors, automatic processing equipment, etc., where dependable performance is required, is announced by Cutler-Hammer, Inc.

The new timer is extremely small in size, being 2¾ in. wide by 4⅞ in. high. This feature is especially desirable in machine design where space is at a premium. Its timing adjustment, easily made from the front of the unit with a screw driver, is unusually simple. Eight turns of the screw gives the entire timing range from 0.3 seconds to 3 minutes. Reset of the timer is practically instantaneous.



This new timer is only 2¾ in. wide by 4⅞ in. high.

The timer is available either with one or two timing steps—the two steps eliminate the need of one timing relay. The two steps of timing are independently adjustable over the entire range.

SOAPSTONES ADDED TO AIRCO WELDING LINE

▲ In response to increasing demands for the item the Air Reduction Sales Company has announced the addition of soapstones to their complete line of welding supplies.

Soapstones also referred to as talc crayons have many uses in the metalworking field. Oxyacetylene burners use them for sketching the contour of shapes to be cut. Welders use them to mark lap joints and stock handlers find soapstones a necessary item for the marking of sheet metal to be stocked.

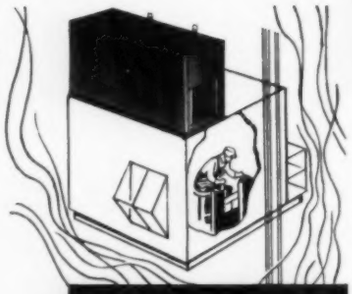
Air Reduction will market a 3/16 in. x ½ in. x 5 in. long soapstone packaged one gross to a carton. Unless specified on an order for other materials these soapstones will be sold in a minimum quantity of 6.

Proved by

PERFORMANCE

in the **HOT** *spots*

Soaking Pit Cranes
Ladle Cranes
Charging Cranes
Electric Furnace Cranes
Forge Shop Cranes
Stripper Cranes
Monocast Cranes
Reduction Plant Cranes
Fabrication Shop Cranes
Annealing Cranes



DRAVO CRANE CAB COOLERS

REPEAT ORDERS from steel, iron and non-ferrous metal producers offer proof of the outstanding results where Dravo Crane Cab Coolers reduce fatigue and improve operator performance. It's worth your while to call or wire Dravo for case history details of these applications.

DRAVO CORPORATION

PITTSBURGH · PHILADELPHIA · CLEVELAND · NEW YORK
CHICAGO · DETROIT · ATLANTA · BOSTON

Sales Representatives in Principal Cities

DRAVO

FOR A GROUP OF OIL BURNERS OF SMALL CAPACITY

BLOOM UNIT ATOMIZER

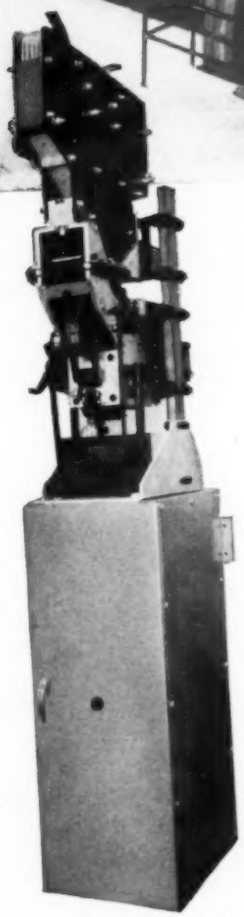
Provides a Method of Burning Small Quantities of Heavy Fuel Oil at Each Burner

The atomizer operates on high pressure steam. It atomizes a reasonable quantity of oil and then divides and distributes this quantity into equal parts, which are delivered to a number of small burners.

An easy system to control. A workable method for a combination oil/gas application to small gas burners. Suitable for oil application to burners requiring 1½ to 3 g.p.h.

BLOOM ENGINEERING CO.

857 W. North Avenue Pittsburgh 12, Pa.



TYPE MT—Single pole, electrically operated breaker. Application Ranges: 250 and 750 V. D-C. Interrupting rating is 150,000 Amp. in capacities 2000 and 4000; 250,000 Amp. in capacities 6000 and above.

Shut-downs are expensive...

PROTECT YOUR VITAL PRODUCTION EQUIPMENT *MORE EFFICIENTLY, MORE DEPENDABLY,* WITH I-T-E'S TYPE MT BREAKERS

● You don't hesitate to buy the best in production equipment—but without electrical power, it's useless. And without adequate electrical protection, you are in danger of losing that equipment at any time. Don't hesitate to get the best in protective switchgear—guard your vital production equipment more effectively with I-T-E Type MT Automatic Reclosing Circuit Breakers.

The MT is a rugged, dependable breaker, specially developed for interrupting extremely heavy direct-currents. It breaks a circuit in .028 second (about 1¾ cycles on a 60-cycle basis) at 25% to 100% of interrupting capacity. Short circuits and overcurrents are cleared instantly, dependably.

I-T-E's Rate-of-Current-Rise Trip anticipates extremely high currents—distinguishes between a useful load of high value and a dangerous fault current—and trips the breaker before the danger peak is reached.

The MT is both electrically and mechanically trip-free on overcurrent, and trips immediately when closed on a fault. A specially designed, self-energizing buffer mechanism smoothly absorbs the shocks of opening—prevents sticking or bouncing.

Although normally built in two styles—for pedestal mounting and for panel mounting—the MT can also be furnished with pantograph-draw-out or truck-mountings if desired.

Further information on the I-T-E MT is contained in illustrated catalog 2202. Send for it today.

The I-T-E Representative in your locality will be glad to advise you on applying the MT—and other I-T-E protective equipment—to your electrical distribution system. Use his services without obligation.

I-T-E R&IE *

MILL TYPE SWITCHGEAR

The Leader In Technical Excellence

I-T-E CIRCUIT BREAKER CO., 19TH & HAMILTON STREETS, PHILADELPHIA 30, PA.—31 OFFICES IN UNITED STATES
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SWITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • AUTOMATIC RECLOSING CIRCUIT BREAKERS • HIGH SPEED CIRCUIT BREAKERS

*FOR POWER SWITCHING EQUIPMENT, REFER TO RAILWAY AND INDUSTRIAL ENGINEERING CO., AN I-T-E ORGANIZATION

Print up to 2000 feet per minute with the

NEW Pannier AUTOMATIC SHEET and STRIP "Master Marker"*

...make complete die change in 30 seconds!

Pannier Engineers, through constant research and experimentation, have successfully developed a marking device for efficiently and automatically printing sheets and strip made from any kind of material.

ANOTHER Pannier FIRST

CHECK THESE MONEY-SAVING ADVANTAGES:

- Prints *all* materials—any thickness.
- Driven by product or conveyor at production-line speed—up to 2000 feet per minute with safety. (Wheel need not ride on product.)
- Complete brass-back die held by spring pin—quickly and easily changed.
- Interchangeable Dovetail National Type for heat numbers, etc.
- One or two dies—any spacing required.
- Felt ink roll with enclosed bearings—inked from face—adjustable to die thickness.
- Adjustable-set-screw-collar crossbar mounting.
- Adjustable die pressure—remains constant despite product irregularities.
- Full counterweight on drive wheel axle for perfect balance.
- Friction drive, Alemite-lubricated-roller-bearing wheel with 30-35,000-mile-life rubber tire.
- Fully guaranteed. **Pat applied for*

See this and other efficient Pannier Marking Devices at Booths 252 and 253, Iron and Steel Exposition, Cleveland, Ohio, Sept. 28-Oct. 1. Or write for complete data today!

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The Pannier Corporation

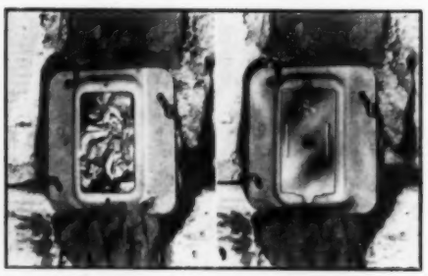
302 Pannier Building

Pittsburgh 12, Pa.

PLASTERGUARD FOR OUTLET BOXES

▲ The O.Z. Electrical Manufacturing Company recently announced the production, in quantity, of the "Plasterguard," an item which is placed in the coverplate frame of outlet boxes, prior to plastering, to prevent plaster from getting into and hardening in screw holes and boxes.

Normally used in square outlet boxes, the Plasterguard eliminates the necessity of an electrician scraping and cleaning boxes before completing final installation. It is estimated by O.Z. that use of Plasterguards will reduce installation time from 15 to 30 minutes. Converting this time to money means a contractor's saving of from 60 cents to over a dollar per outlet, depending on local labor rates.



Left, the old way — with newspapers stuffed in box. Right, the new way — note the tight fit.

Plasterguards fit within the frame of the outlet box and are held there by four spring ears. They provide an efficient replacement for the outmoded method of stuffing newspapers into the box.

In designing Plasterguards, O.Z. has taken into consideration the troublesome fact that some plasterers are accustomed to facing completely over the box. This practice entails additional time in tapping or checking blueprints to discover the location of the hidden box. It is an expensive time factor and one that is eliminated with Plasterguards because the steel used in manufacture reacts with lime in the plaster, showing a brown spot on the wall which easily locates the concealed box.

By simply pressing the Plasterguard into the box and removing, the electrician leaves a clean cut, well defined edge to the plaster. He is immediately ready to pull the wires since there is no plaster within the box to be scraped and cleaned out, nor does he have to retap any screw holes.

In quantities of 100 or less, contractor's price for Plasterguards is a low 4 cents each. This is thought to be exceptionally nominal for it takes only seconds for the electrician to insert and remove the Plasterguard, and Plasterguards may be straightened and re-used several times.

NEW UNIT HEATER HAS CAST IRON CONSTRUCTION

▲ New gas fired unit heaters that feature cast iron construction in both the heat exchanger and the combustion chamber have been placed on the market by Automatic Gas Equipment Company. They are known as Pittsburgh gas unit heaters, Series "C."

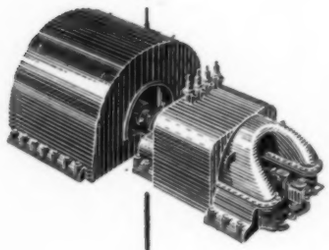
Cast iron is used for the heat exchanger and combustion chamber because it is the best material to withstand the corrosive effects of the products from combustion of gases. They are cast in one piece, and the extended heating surface fins on the heat exchanger are cast integral.

These gas unit heaters have been designed to consume exactly the

RECORD SEAMLESS PIPE

Seamless steel pipe 26 in. in diameter, that's two inches wider than was ever before produced, is being turned out at the Lorain, Ohio plant of National Tube Company, in increasing quantities to help alleviate the gas and oil shortage that has plagued American industry for such a long time. John Lorince is sawing a test piece from a 26 in. pipe cut-off in the lab at this U. S. Steel plant.

New life expectancy for impeller blades ...with Super-Clean Air!



ABRASIVE dust and dirt entering a high-speed rotary blower are sure death to steel impeller blades. When these blades hit this grit-loaded air, it's like trying to cut through a sandstorm. Rapid wear and erosion result, and you have a replacement problem on your hands.

But there's a sure-fire answer to this problem: AAF Multi-Duty Air Filters. Installed at the blower intake, AAF Multi-Duty filters out abrasive particles—preventing this killing dust and dirt from reaching the rotary blower.

The AAF Multi-Duty is an automatic, self-cleaning air filter. Overlapping panel construction combines self-cleaning and high efficiency air cleaning as integral functions of the operating cycle. Uniformly constant air supply is assured as operating resistance remains fixed when once established for a given dust concentration.

Increase the life expectancy of your impeller blades with AAF Multi-Duty Air Filters —you'll find the cost is only a fraction of the savings. Write for complete information or call your nearest AAF representative.

American Air Filter Company, Inc.
302 Central Avenue, Louisville 8, Ky.
In Canada: Darling Bros., Ltd., Montreal, P. Q.

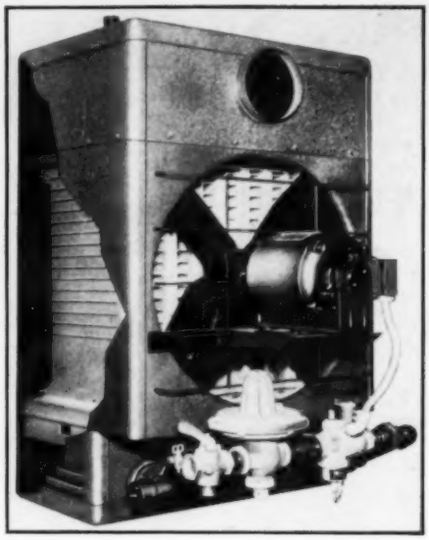
®AAF
AIR FILTERS
AND DUST CONTROL EQUIPMENT

right amount of air to support perfect combustion but without permitting an excess of air to lower heating efficiency. This is accomplished by means of a built in draft hood which absorbs all excessive chimney action and thereby conserves heat. The heater does not depend upon forced draft from the fan for either the primary or secondary air supply. For this reason there is no possibility of variation in the air supply to the burners resulting from changes in fan speed or louver adjustment. By the use of adjustable horizonal louvers, warm air can be directed to any desired level.

A tested and proved safety pilot is used on these heaters to automatically turn off the gas if the pilot light goes out or if it burns too low to insure perfect ignition. The draft diverter is absolute protection against any possible down drafts through the chimney.

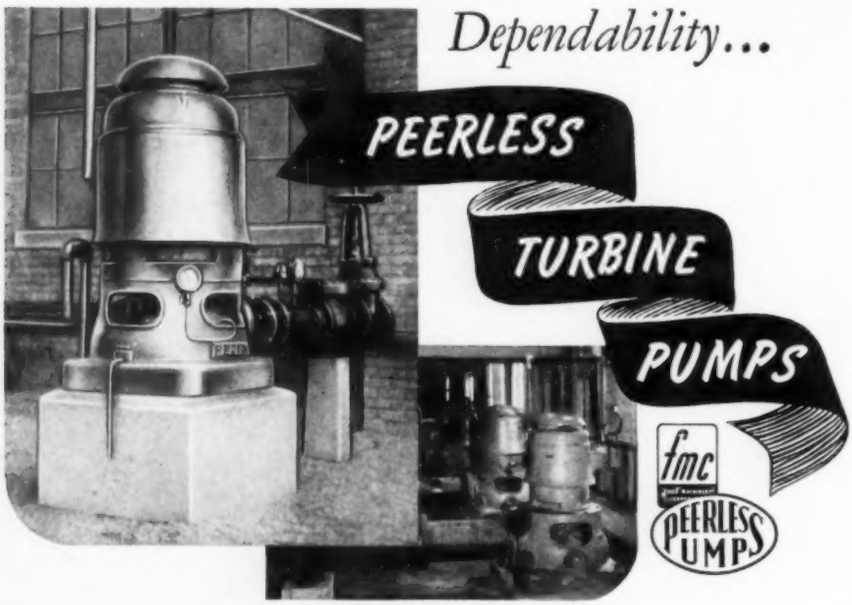
The gas unit heater comes as a complete heating unit in itself. It can be installed wherever warm air is required over a given area—for heating, for ventilating, or for drying. The motor and fan in the unit are powerful enough to deliver the air exactly where needed and in the right quantity.

The Series "C" heater is approved by the American Gas Association.



Cast iron is used in this heater to withstand corrosion from gas combustion.

The Standard of Deep Well Turbine Pump Dependability...



Flexibility to Meet Your Requirements

FOR WATER SUPPLY, PROCESSING, RECIRCULATION, FIRE PROTECTION

CAPACITIES: *15 to 30,000 GPM* **LIFTS:** *To 1000 ft.* **HP RANGE:** *1 to 1000 hp*

Look to Peerless for dependable turbine pumping performance, economy of operation and top flight efficiency. Peerless turbine pumps are extremely simple in construction, flexible in operation, compact in installation and are easily adapted to handle practically all types of pumping operations. They embody all modern refinements of design and construction. They are available in deep well types, close-coupled types for short or medium settings and Underwriters' approved types for reliable fire protection service. Plan with Peerless for unbiased vertical turbine pump recommendations.

CHOICE OF DRIVES—
OIL OR WATER LUBRICATION

All forms of power drives or adaptations in a full range of sizes and power to meet your requirements. These include Motrubo-electric hollow shaft drive, Gearturbo-right angle gear drive, Veeturbo (V-belt) and Belturbo (flat-belt) drives. (Right angle gear drive illustrated.)

For most services... in all industries

Request descriptive Bulletin B-141-1

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TAP IN 175-TON OPEN HEARTH FURNACE

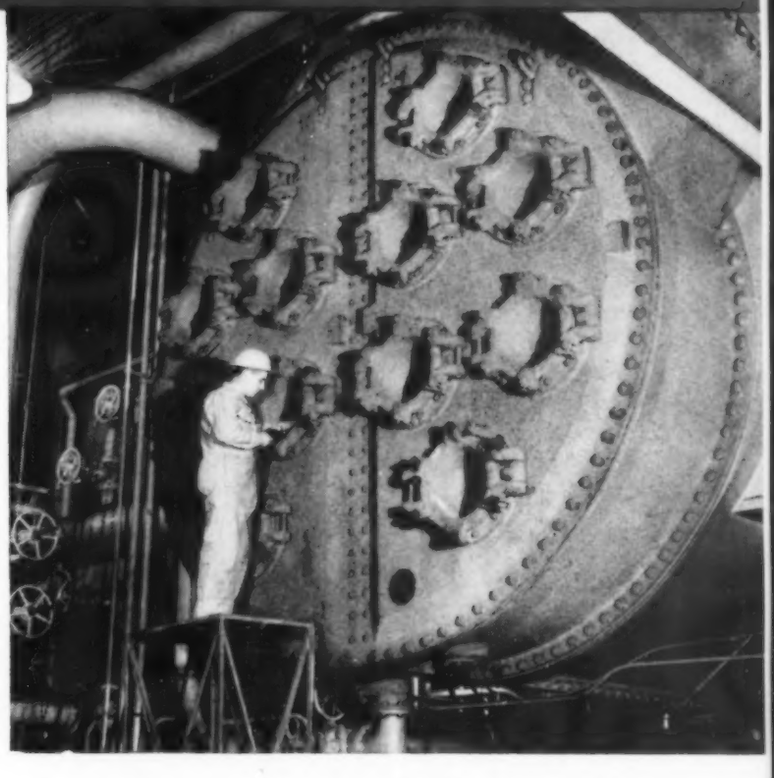
▲ At the Otis works of Jones and Laughlin Steel Corporation, on July 4, the new 175-ton open hearth furnace, which has just been completed, was tapped. This $2,000,000 furnace project will add 75,000 tons of steel to the annual ingot capacity of the Otis works at Cleveland. The furnace is of the most modern type and was built by the Loftus Engineering Company.

INDUSTRIAL PAINT FOR SAFETY USE

▲ Substantial progress in the elimination of one of the most common industrial accidents—slips and falls resulting from hazardous footing—is being accomplished by the increasing use of a new safety floor floor finish, "Traffic-Tred," a product of the in-

DOWELL

SPECIALISTS IN SCALE AND SLUDGE REMOVAL WITH CHEMICALS



clean condensers rapidly—

the chemical way!

Engineers responsible for power plants in many industries know that *clean* condensers and boilers are important factors in *keeping down costs.*

To help you keep down costs and maintain designed operating efficiency in many types of heat exchange equipment, Dowell offers a fast, reliable chemical scale removal service which has been proved in thousands of successful cleaning jobs.

Dowell engineers fill the equipment with liquid solvents designed to dissolve and disintegrate the scale and sludge deposits which retard heat transfer. Dismantling is unnecessary; down time is reduced to a minimum.

Dowell engineers are experienced, know which solvents to use, and have the necessary equipment—special truck-mounted tanks, pumps, heaters and chemical proportioners—to make possible control of each stage of the job.

To clean condensers, boilers, many other types of heat-exchange equipment, water lines and water wells—call Dowell. Ask for literature and a prompt estimate on *your* job.

DOWELL INCORPORATED · TULSA 3, OKLAHOMA

SUBSIDIARY OF THE DOW CHEMICAL COMPANY

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New York	Buffalo	Wichita	Mt. Pleasant, Mich.
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DOWELL

A SERVICE ORGANIZATION

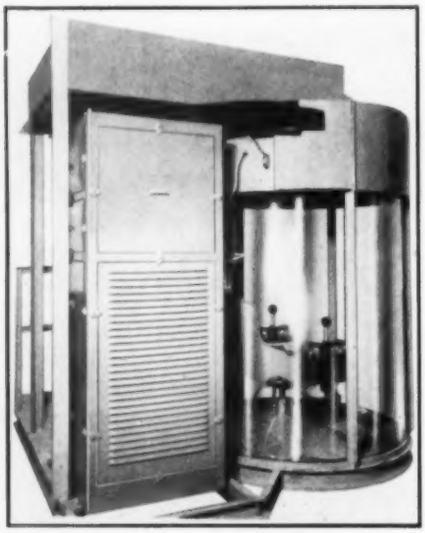
dustrial safety products division of Watson-Standard Company.

"Traffic-Tred," the material of a thousand uses, is an abrasive floor coating which is applied like paint. It dries to a hard, rough surface with a texture much like coarse sandpaper. It works equally well on steel, wood or concrete, removing most of the danger from walking areas subject to dampness, greasiness and other slippery conditions.

CONDITIONING UNIT HAS FILTER FOR DIRT

▲ The Lintern Aire-Rectifier (148 AC-14) with air-cooled condenser is claimed to provide trouble-free cooling with extremely low service requirements. It is equipped with a screen-type cleanable filter for the removal of industrial dirt, down to four microns in size, from the air delivered to the cab for ventilation.

The cooling equipment included in this model Aire-Rectifier is capable of maintaining a properly designed and insulated cab up to 200 cu ft capacity at a temperature of 85 F



Industrial firms are discovering that conditioning units pay for themselves by aiding the productivity of individual workers.

with an ambient temperature as high as 170 F. Model 148 AC-14 F of the same capacity is for the more conventional type of cab with the unit located on the footwalk above the cab.

Many steel companies, it is reported, are using Lintern Aire-Rectifiers to provide better working conditions and achieve higher production; experience has shown that these two go hand in hand with low labor turnover.

ALABAMA PIPE MILL SHIPS LARGE PIPE ORDER

▲ The first shipment of pipe from Republic Steel Corporation's new large diameter pipe mill left Republic's sprawling Gadsden, Alabama, plant consigned to the Southern Natural Gas Company, Birmingham. The shipment is the first of a total of 140 miles of 24 in. pipeline which Republic will make on the new mill for the gas company. The pipeline will greatly increase the amount of natural gas which will be brought into the Birmingham area, for many years deficient in fuel supply for its industries.

The first shipment amounted to about two miles of pipe. When operating at full capacity, the mill will produce about 65 miles per month.

E. I. Evans, manager of Republic's operations in the south, said that the mill had been designed and built in what he believed to be record time.

"When we undertook this job last summer, we set up a schedule calling for operation to commence this June. Actually, I don't think any of us believed this could be accomplished so it is with great satisfaction that we report this first shipment."

Mr. Evans pointed out that although the mill is now producing commercial tonnages, it will be some time before it is operating at its intended capacity.

"We must train crews," he said, "and, of course, we will encounter the usual production 'bugs' which we will have to work out as they appear. It will probably be the first of next year before we are producing at full capacity of this mill.

"When the pipe mill is producing at capacity, we will use most, if not all, of the output of our plate mill. We have notified the relatively few customers whom we have supplied with plates in the past that when that time comes, we may not be able to deliver any plate to them. The tremendous need for natural gas in this area has convinced us that this course is for the greatest benefit of all concerned. Since the pipe mill will not take our full production of plates for some period of time, we will meanwhile be able to supply a sizeable percentage of the needs of the customers we have been serving."

The pipe mill is able to produce electrically welded steel pipe in diameters from 20 to 30 in. and in lengths of 30 ft. In some instances, two sections will be welded together before leaving the plant so that shipment of single sections 60 ft in length will be possible. Construction of the mill has made necessary erection of two buildings and open storage areas. Eventually, employment of up to 300 additional persons will result from placing the mill in full operation. The entire output of the mill is scheduled for many months in the future. Shipment of the pipe is being made by both railroad and motor truck.

METALS HANDBOOK READY FOR DISTRIBUTION

▲ The new 1948 edition of Metals Handbook, is just off the press and ready for distribution. This edition contains 1,444 pages (8 by 10 inches), and is divided into four principal sections: 1. General, 2. Ferrous Metals, 3. Nonferrous Metals, 4. Constitution of Alloys.

The 1948 edition, price $15.00, can be obtained by writing the American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio.

BETHLEHEM PUTS $100,000 INTO METAL RESEARCH

▲ The Bethlehem Steel Company, second among the world's producers of steel, has invested $100,000 in the University of Chicago's multi-million dollar program of atomic and metal research.

In announcing the investment, E. G. Grace, chairman of the board, said Bethlehem had become an industrial member of the university's Institute of Metals as a "contribution to science and public welfare."

"The discovery and harnessing of atomic energy may prove to be the most significant material development in the history of man," he said. "It is hoped that the Chicago studies may lead, in due course, to a much greater availability of energy, with consequent improvement in the general standard of living."

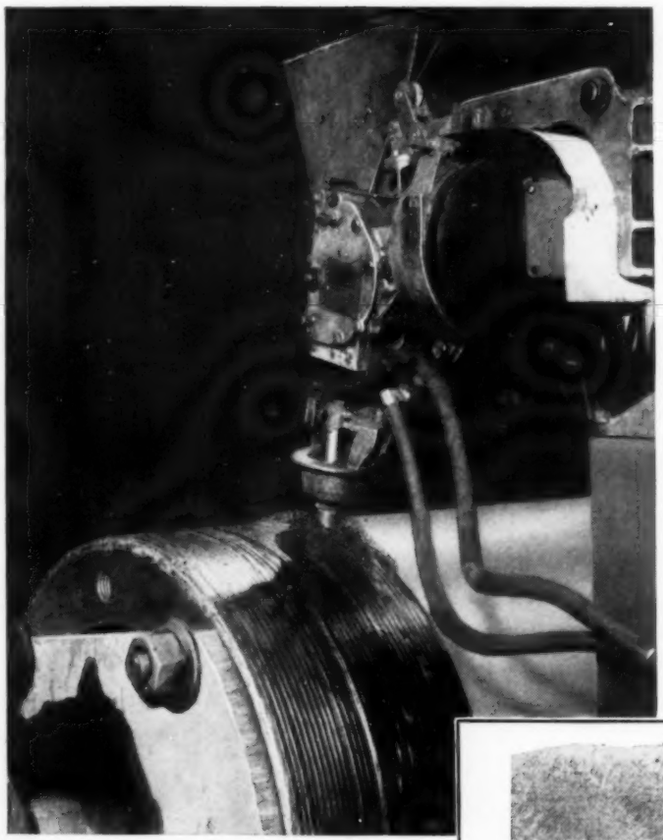
Bethlehem brought to 13 the number of industrial organizations supporting a unique industry-education

Give New Life to Worn Parts

. . . . . *Rebuild Them by the UNIONMELT Welding Process*

This automatic process saves time and money—welding is fast—parts are returned to service quickly—new surface is often superior to original—

Almost any part that can be suitably positioned can be rebuilt by the UNIONMELT welding process. It has been used successfully on parts such as steel mill rolls, guides, mandrels, journals; wheels for locomotive cars and cranes; pipe molds, and press plungers and cylinders.



Rebuilding a 24 in. diameter press plunger.

Deposits of almost any thickness can be made of—

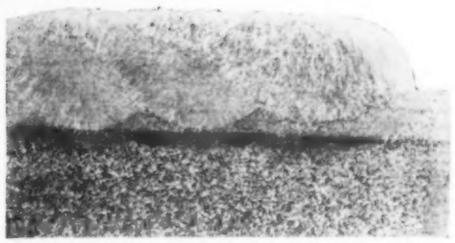
High carbon, flame-hardenable steels

Wear-resistant and hard-facing materials

Corrosion- and heat-resistant steels

With the UNIONMELT electric welding process clean, dense, uniform weld metal can be deposited at the highest known welding speeds. There is no glare, flash, or spatter during welding. If a finished surface is needed, only minimum machining is required because of the smoothness of the weld deposit.

There are many LINDE methods of joining, rebuilding, forming, cutting and treating metals. LINDE Engineering Service can help you in production, construction, and maintenance. Just call the nearest LINDE office.



A flat surface is produced by offsetting each bead.

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THE LINDE AIR PRODUCTS COMPANY

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research program being carried on in the university's Institute of Metals, Institute of Nuclear Studies and Institute of Radiobiology and Biophysics.

As an industrial member of the research program, Bethlehem will take part in quarterly scientific conferences at the university to discuss current progress and techniques.

Industrial members also receive advance reports—three to six months before general publication—on all phases of research. As the university does not intend to patent any development except where the patent may be necessary to protect against misuse, this means that industrial members utilize any industrial application which may develop from contact with the university's atomic scientists and metallurgists.

Other industrial members of the institute include:

Westinghouse Electric Corporation, United States Steel Corporation, Standard Oil Company of Indiana, Aluminum Company of America, Beech-Nut Packing Company, Standard Oil Development Company of New Jersey, Pittsburgh Plate Glass Company, Shell Oil Company, Inland Steel Company, Sun Oil Company, Celanese Corporation of America and Commonwealth Edison Group.

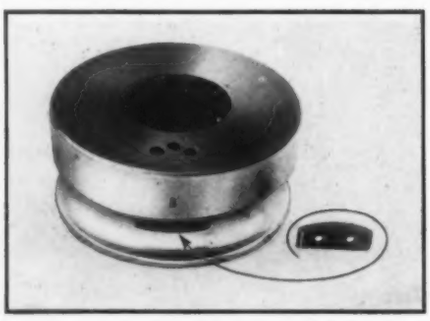
ROLL DIE FOR MARKING TUBING

▲ A new-style insert roll die for marking copper or brass pipe and tubing is now being manufactured by the M. E. Cunningham Company. Identified as the "Kop-R-Tube" insert marking roll, it can be furnished for use in marking machines or in standard coiling machines used for coiling the copper tubing. It is grooved to suit the size of tubing to be marked, and is equipped with a recess slot for changeable marking die inserts. These dies can be easily and quickly changed as they become worn.

This new insert roll die replaces previous solid-style marking rolls which had to be completely re-machined and engraved when lettering became worn. Die inserts can be carried in your stock, and can be removed and replaced by your own maintenance department, thereby reducing the number of rolls required. Maintenance cost is reduced, and the usable life of the roll is prolonged.

Machined to precision specifications, rolls are made to suit machines you now have in use, and includes ball bearing, replacing friction bearing to further improve efficiency. Rolls can be designed for any special machine, and are made for any size tubing, ¼ in. size, and larger.

Machined to precision specifications, rolls are made to suit machines now in use.



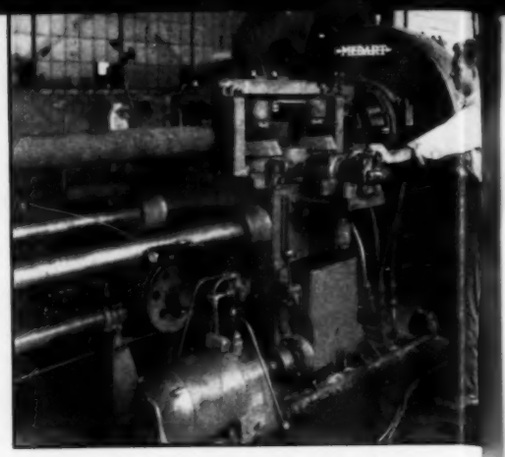
BAR AND TUBE TURNER HAS ROLL-TYPE FEED

▲ A complete new line of centerless bar and tube turners is now being offered to the trade by Medart Company. This new line is known as the "RFRG" type turner, and it includes three standard sizes for turning bars and tubes from 1 in. to 10 in. in diameter.

These new turners feature a new roll-type feed and an infinitely variable ratio of bar feed to cutting tool speed. This new roll-type feed gives a positive, steady feed of the bar or tube through the cutters. An equalizing device, for centering the workpiece in the cutterhead, is incorporated into this feed. This makes possible equal removal of stock around a bar surface and concentric turning on tubes.

Separate drives are arranged for the cutting tools and the bar feed, so that an infinitely variable number of combinations are possible between these two to give close tolerance and superior finish for precision turning, or high production turning for a scalping operation.

The turner retains the two, outboard mounted, cutterhead type of spindle which has given maximum turning flexibility on past models of Medart turners.



These new turners have an infinitely variable ratio of bar feed to cutting tool speed.

Runner-bar sections are arranged on both the input and output sides of the spindle, with individual grip carriages on each to maintain positive gripping of the workpiece and carry all torque loads. The speed ranges built into the machine allow turning at speeds as high as any present day high-speed cutting tools will permit. Fully automatic pushbutton type operation is designed into the turners, making it unnecessary for the operator to leave his post.

FRENCH FIRM TO MAKE ELECTRIC TRUCKS

▲ A French affiliate of the Automatic Transportation Company, 149 West 87th Street, Chicago, Automatic S.A.R.L., has started producing electrically propelled materials handling equipment to meet the demand in nine European and North African countries. Production is under way on the "Transporters" and "Skylift" models.

Announcement of the new plant, organized in August, 1947, located at 16 Rue de Belzunce, Paris, 10, was made by Elmer F. Twyman, general manager of Automatic. Mr. Twyman said that the objective of the new plant is "to create in France a company to manufacture, promote, and sell modern materials handling equipment in that area. By this we will achieve a greater service in meeting industrial requirements, and aid in the rehabilitation and redevelopment of shattered essential industries."

Nations to be served by Automatic S.A.R.L. are France, Holland, Belgium, Luxembourg, Italy, Switzerland, Spain, Algeria, and Morocco.

For users in these countries, savings will be notable, Twyman said,

ONLY PROPER COMPOUNDING AND FRICTIONING GIVE *Longest-Lived* SPLICING TAPES

Okonite Rubber and Manson Friction Tapes provide every essential characteristic

For over 60 years, electrical men who want the best have specified Okonite Rubber and Manson Friction Tapes. With today's emphasis on lasting values, these tapes are more important than ever.

Properly compounded from Up-River Fine Para rubber, Okonite Tapes fuse into a homogeneous wall of tough insulation, high in dielectric strength, elastic, resilient and permanently waterproof.

In Manson Friction Tapes, new, naturally tacky rubber has been properly frictioned into a closely-woven fabric to give the true adhesiveness plus the aging and weathering qualities needed for lasting protection of the insulating compound.

with today's high installation costs* only the *Longest-Lived* splices will be economical

* The lifetime cost of an electrical splice is more important — and more economical in the long run — than the first cost of the tape that makes it. Okonite and Manson Tapes are built to deliver maximum value when you consider (1) seriousness of a failure and (2) doubled installation cost when splice has to be rebuilt.

FOR ELECTRICAL MEN IN INDUSTRIAL PLANTS

Okonite and Manson Tapes are widely used in many kinds of field work. Whether for splicing underground cable, risers or overhead lines, Okonite and Manson Tapes offer not only long service life but also ease of handling and splicing — with resulting lower application costs.

Let us send you a ½-pound trial can of each of these tapes — free — enough to make a dozen or more splices in #6 wire. See for yourself how much better jobs you get. Just make the request on your business letterhead. The Okonite Company, 19 Canal Street, Passaic, N. J.

6620

OKONITE (OKONITE SINCE 1878) **and MANSON TAPES**

THE BEST TAPE IS YOUR BEST POLICY

because of vastly reduced shipping costs, lower production costs, and in many cases elimination of tariff charges.

Units to be made in the Paris factory include the "Skylift" fork trucks, up to 6,000-lb capacity, and the "Transporter" of electric motorized hand trucks.

WATER CONFERENCE TO BE OCTOBER 18-20

▲ The Ninth Annual Water Conference of the Engineers' Society of Western Pennsylvania will be held in the Hotel William Penn, Pittsburgh, Pennsylvania, on October 18, 19, 20, 1948.

ELECTRIC RADIANT HEATERS FOR HIGH HEAT INTENSITY

▲ High heat intensity and utilization of almost the entire infrared band result in a new and improved type of infrared heating with the rugged Chromalox all-metal electric radiant heaters just announced by Edwin L. Wiegand Company. These glassless, glareless heaters were designed for drying, baking, preheating and dehydrating where a longer-wave infrared heat source is desired and where rugged, all-metal construction is preferable.

This new electric radiant heater has a high-temperature enclosed type heating element mounted in a rigid extruded aluminum body with a very efficient reflector sheet of highly polished Alzaked aluminum, which can be easily cleaned or replaced if necessary. Tongued and grooved sides and two sliding captive bolts facilitate fabrication of heater sections into various working patterns.

The heating elements are mounted at the focus of a parabolic reflecting surface, which results in maximum heat radiation uniformly distributed over the surface to be heated. A negligible amount of visible light is produced from the Inconel-sheathed tubular electric heating unit which operates at temperatures of 1000 to 1400 F, depending upon wattage of the heating element. The user has a choice of wattage ratings to suit his operating conditions and to accomplish the results desired.

Glassless construction permits an unobstructed, unfiltered path of infrared radiation of the longer wave lengths. It can be truly said that to this radiant heater all colors appear as black for it is the longer wave lengths that are absorbed almost equally well by surfaces of all types, colors and textures.

The interlocking and sliding bolt features permit maximum flexibility in fabricating groups of heaters into patterns—arcs, circles, squares, etc. —for almost every conceivable infrared application. Adjacent sections can be interlocked on a plane or, by means of hinge-acting joints, can be rotated up to 25 degrees. Simple angle-iron frames can be formed to support the assemblies after the working pattern has been determined.

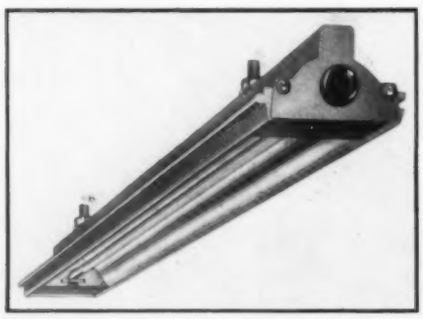
The assemblies are only four inches in depth and, because of the shallow construction, the heat source can be brought closer to the work. Compactness is a big advantage in many applications where space is limited.

These electric radiant heaters, because of their glassless construction, are ideally suited for use with conveyor belts. In general, they are desirable for any drying, heating, baking or dehydrating job where radiant heat is most efficient.

Comparatively inexpensive Chromalox radiant heaters can be used to increase work output in existing ovens without raising oven temperature, increasing oven size or adding insulation. It's the combination of infrared heat and convected heat that speed up the operation. Chromalox radiant heaters can be used safely in this manner in ambient temperatures of 400 F or higher.

Chromalox radiant heaters are designed so that heating elements of same or different wattage can be changed right on the job in a minimum of time.

These heaters are ideally suited for use with conveyor belts.



LUKENS OBSERVES 138th ANNIVERSARY

▲ On July 2 Lukens Steel Company observed the 138th anniversary of the continuous making of iron and steel on the banks of historic Brandywine Creek, in Coatesville, under a continuous line of family ownership and management.

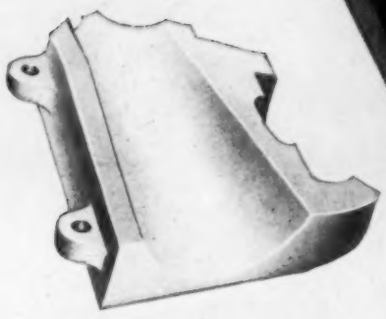
Three descendants of Isaac Pennock, of the "foundry family" are still active in Lukens management, serving as officers and directors. They are Charles Lukens Huston, first vice president; Charles Lukens Huston, Jr., vice president and executive assistant to the president; and Stewart Huston, secretary.

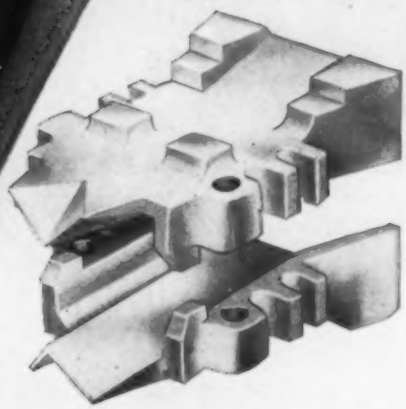
Isaac Pennock was criticized severely by his family for selling his farm and entering the "hazardous iron business when wheat was selling for $3 a bushel, and the influence of Great Britain was detrimental to the success of the iron business." But Pennock persisted, and his "Brandywine Iron Works and Nail Factory" has grown into Lukens Steel Company, employing more than 5000 people today, with a plant covering almost 600 acres. Its facilities include the world's largest plate mill, the world's largest and most modern sodium hydride descaling plant, and the world's largest flanging machine, for spinning heads for tanks, boilers and pressure vessels. Lukens sales, in 1947 of its steel plate and steel plate specialties, including those of its two divisions, By-Products Steel Company and Lukenweld, totaled in excess of 52 million dollars.

Lukens Steel Company was named for Rebecca Lukens, eldest daughter of Isaac Pennock, who was married to Dr. Charles Lukens, who forsook the medical profession to operate the mill for his father-in-law. In 1825, Dr. Huston died, and responsibility of running the business and raising her family of five children, was left to Rebecca Lukens. So successfully did she manage, despite the general feeling of the time that petticoats and pig-iron don't mix, that she became outstanding as the "woman of steel." Rebecca's daughter, Isabella, was married to Dr. Charles Huston, who were the parents of Charles Lukens Huston, and the grandparents of Charles Lukens Huston, Jr., and Stewart Huston.

TRANTINYL

GUIDES THE STEEL INDUSTRY





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TELLS YOU HOW:

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The booklet shows how large and small users have saved hundreds of dollars by eliminating many custom-built brushes and standardizing on a few types and grades that can be bought in quantity . . . and do the job just as well.

TO SAVE MONEY ON BOOKKEEPING, BILLING, AND ACCOUNTING

The booklet explains how standardization results in fewer orders to place, with savings all down the line — in stock records, ordering, and payments. Ordering is even further simplified through National Carbon Company's unique system of *"RC Numbers"*— code numbers that cover complete specifications on a given brush without laborious detail.

TO CUT INVENTORY AND STORAGE SPACE

The booklet points out that brush standardization means greatly reduced brush stock — which means less handling time and cost, less money tied up in inventory, fewer requisitions to prepare.

FREE!

Get your free copy of this attractive 24-page booklet, ***"Standardization of Carbon, Graphite and Metal-Graphite Brushes for Motors and Generators."*** Better yet, let us present it in person. Write to National Carbon Co., Inc., Dept. IS.

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Unit of Union Carbide and Carbon Corporation

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Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

Personnel News . . . .

Robert L. Hanson has been engaged as manager of the Allen-Bradley district office in the Bessemer Building, Pittsburgh, Pennsylvania.

He is a graduate in electrical engineering of the University of Wisconsin, and has had extensive industrial engineering experience with Wagner Electric Corporation, Crocker-Wheeler Company, and Sperry Corporation.

William D. Taylor, who has been associated with Lukens Steel Company, Coatesville, Pennsylvania, since his graduation from Swarthmore College in 1936 as an engineer, has been named as superintendent of the inspection department of Lukens and its divisions, By-Products Steel Company and Lukenweld.

At the same time it was announced that the inspection department which heretofore had been associated with the metallurgical department of Lukens, is now a separate and distinct department under Mr. Taylor. Most recently Mr. Taylor has been assistant metallurgical engineer. Previously, he was an engineer of tests, and a technical assistant in Lukens metallurgical department.

D. R. Loughrey, formerly assistant superintendent, bessemer department, has been appointed superintendent, open hearth and bessemer department, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

L. A. Lambing was named as assistant general superintendent, Pittsburgh, Pennsylvania, works, Jones and Laughlin Steel Corporation. Mr. Lambing was formerly superintendent of the open hearth and bessemer department.

C. T. Spivey has been appointed director for industrial relations for Columbia Steel Company to succeed **Joseph L. Turner** who has been promoted to an executive position with the United States Steel Corporation of Delaware at Pittsburgh. Mr. Spivey will make his headquarters in the San Francisco office of Columbia. **Robert R. Wolfenden** has been appointed product manager for tin mill output; **R. E. Smice** has a similar position for heavy products; and **W. M. Jarrard** has been made products manager for wire mills, all of Columbia Steel Company at Pittsburg, California. Mr. Jarrard replaces **Robert C. Baker** who has retired after 43 years of service with the U. S. Steel Corporation and its subsidiaries. **Joseph A. Burgard** has been appointed to the position of technical sales representative for the general sales department of Columbia Steel Company, San Francisco.

Peter Robertson, for the past four years works manager of the Truscon Steel Company in Youngstown, will become assistant to district manager of Republic Steel Corporation's Cleveland district.

Mr. Robertson, a native of Glasgow, Scotland, came to this country at 16 and became an apprentice tool maker at the General Electric Company in Schenectady, where he later served four years as a gear department foreman. At the completion of a special executive training course, he spent two years in industrial engineering work for that company. Joining Republic in 1934, he assisted in the introduction of modern production methods at the Berger Manufacturing Division, Canton, and spent two years at Truscon in Youngstown in similar work. He was promoted to assistant chief industrial engineer of the corporation in 1938 and played a prominent part in the conversion of Republic's manufacturing divisions to war products during the war.

Douglas K. Forsyth was named works manager for Truscon Steel Company, Youngstown, Ohio. Mr. Forsyth started with Truscon in 1919, following graduation from Youngstown schools. He was a departmental

ROBERT L. HANSON

WILLIAM D. TAYLOR

D. R. LOUGHREY

overhung loads?

DE LAVAL WORM GEARS WITH SLEEVE BEARINGS

For carrying heavy overhung loads imposed by gears, cranks, pulleys or sprockets, De Laval Worm Gear Speed Reducers can be furnished with generously proportioned sleeve bearings on the output shaft; a choice of either sleeve bearings or anti-friction bearings being available in most models. Both can be depended upon for trouble-free service.

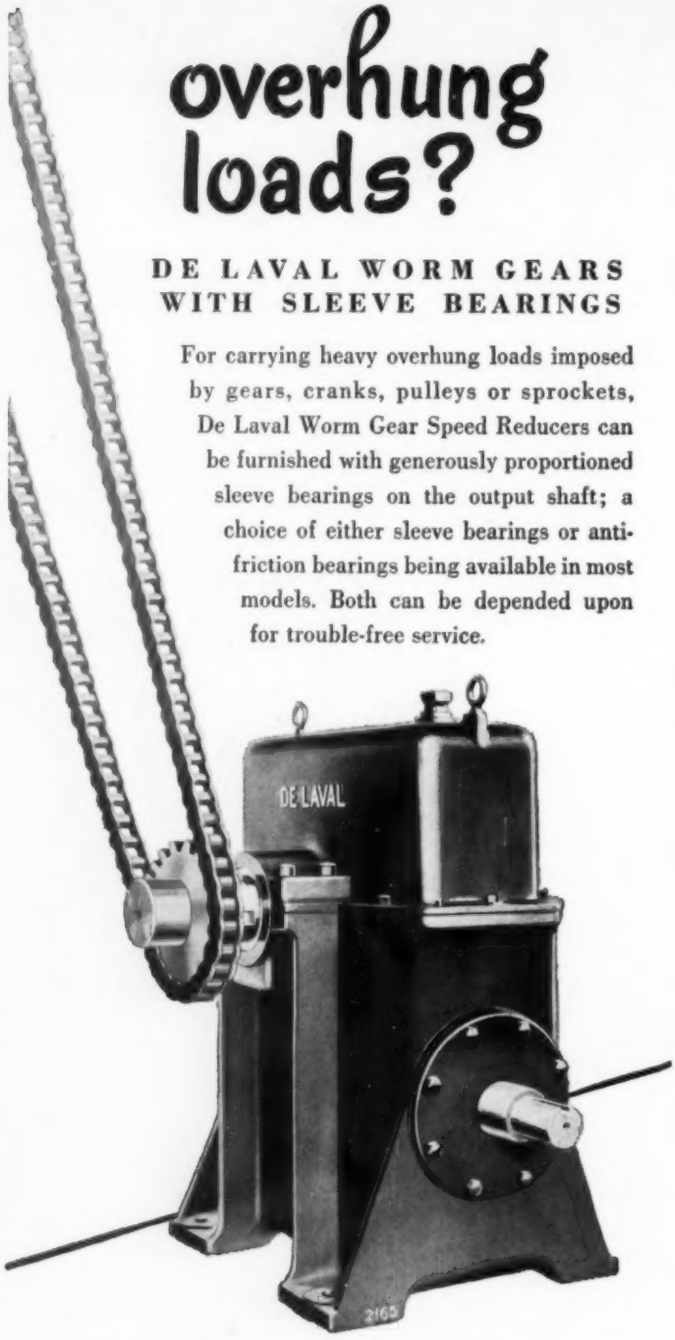


ILLUSTRATION NOTE: Use of an auxiliary chain and sprocket, with the worm gear speed reducer carrying the major reduction, allows ease of subsequent change of over-all speed reduction, facilitates interchangeability of speed reducers throughout the plant, and reduces installation costs.

If your speed reducers require an overhung load, consult a De Laval representative.

ONE OF 93. This single reduction De Laval Worm Gear Speed reducer is available with many standard gear ratios and is but one of 93 sizes and types of standard De Laval Worm Gear Speed Reducers.

Worm Gear Division WG-17

DE LAVAL

De Laval Steam Turbine Co., Trenton 2, N. J.

TURBINES • HELICAL GEARS • WORM GEAR SPEED REDUCERS • CENTRIFUGAL PUMPS
CENTRIFUGAL BLOWERS AND COMPRESSORS • IMO OIL PUMPS

superintendent from 1935 to 1938 and has been assistant plant manager since that time.

John H. Hamill was appointed superintendent of the structural steel department of Truscon Steel Company, Youngstown, Ohio. Mr. Hamill has been employed at Truscon since 1922.

Norman P. Hitchcock has been appointed assistant superintendent of maintenance (electrical) at Brier Hill works of Youngstown Sheet and Tube Company, succeeding **Louis C. Breetz,** retired.

Mr. Hitchcock came to Youngstown Sheet and Tube Company in 1933 as a power house repairman at Campbell, Ohio, from RCA Victor Company at Camden, New Jersey, where he was a test engineer. Three years later he was made chief electrical inspector at Campbell and held this position until 1940 when he was transferred to Brier Hill as general foreman, nights (maintenance).

He attended North Jackson and Rayen schools, went to Western Reserve University where he received a bachelor of arts degree and then to Case School of Applied Science where he received a bachelor of science degree in electrical engineering.

Louis E. Feisner has been appointed superintendent of mechanical maintenance, universal, hot and cold strip mill department, Midland works, Crucible Steel Company of America, Pittsburgh, Pennsylvania. He was previously with Braeburn Alloy Steel Corporation.

Joseph L. Herman who has been with Keystone Steel and Wire Company, Peoria, Illinois, for 49 years, has retired. Mr. Herman joined the company as a spooler boy. He was successively fence machine operator, foreman of the wire drawing department and wire mill superintendent.

Alan H. Ferguson, formerly electrical engineer, H. A. Brassert and Company, New York, New York, is now chief electrical engineer, Columbia Steel Company in Oakland, California.

Wilson A. Jones has been appointed director of engineering industrial relations, Ford Motor Company, Dearborn, Michigan. Mr. Jones formerly served as personnel representative for the engineering division.

Howard Marston, for the past 10 years sales and service engineer at the Boston branch of Minneapolis-Honeywell Regulator Company, has been appointed industrial manager of the Brown division of the company in Minneapolis and St. Paul.

Earl S. Bush has been named Chicago industrial sales engineer for the steel industry for the Brown division of Minneapolis-Honeywell Regulator Company, succeeding **A. J. Potts. Larry E. Singleton** will succeed Mr. Bush as the Chicago branch industrial service manager.

William B. Kempton has been appointed assistant manager of the hardware products department of Wickwire Spencer Division, Colorado Fuel and Iron Corporation, Buffalo. Mr. Kempton has been a member of the Boston district office for many years.

H. R. Klepinger has retired as superintendent of special assignments for American Steel and Wire Company, Cleveland.

John K. Killmer, who has served Bethlehem Steel Company, Incorporated, Bethlehem, Pennsylvania, in various capacities since 1923, has been appointed metal-

lurgical engineer on the staff of the operating vice president to succeed **Henry Wysor,** who has retired.

P. F. Bauer has been named manager of a newly formed central region of Allis-Chalmers Manufacturing Company's general machinery division, with headquarters in Cleveland. Mr. Bauer joined Allis-Chalmers in 1928, and served as a salesman in the Pittsburgh district office until March, 1942, when he was named manager of the firm's industrial sales department.

Walter P. Barrett has been appointed manager of the New York district office of Dravo Corporation. His office is located at 30 Church Street. Formerly assistant manager of the corporation's machinery division district office in Philadelphia, Mr. Barrett has been with Dravo 13 years.

E. L. Tindall has been appointed Pittsburgh district engineer for Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania. Mr. Tindall formerly was chief engineer of the Edgar Thomson works, Carnegie-Illinois Steel Corporation, Braddock, Pennsylvania.

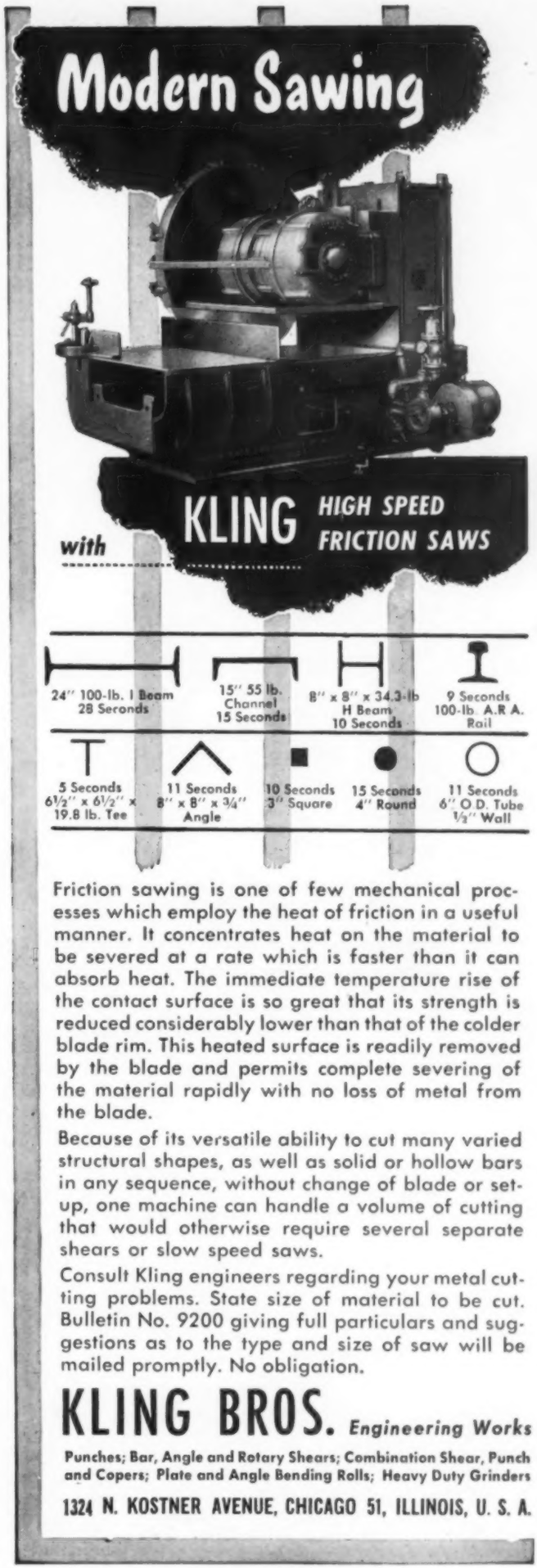
Fred S. Bacon, Jr. has been appointed assistant general sales manager of Rockbestos Products Corporation, New Haven, Connecticut. In his new post, Bacon will have immediate responsibility for general sales, advertising, and sales promotion. He comes to Rockbestos

FRED S. BACON, JR.

from Westinghouse Electric Corporation where he held the position of manager of the central station division department at Boston. He has been with Westinghouse since his graduation from Northeastern University in 1936.

D. S. Lee, former district manager of Rockbestos Products Corporation's Buffalo office which has been discontinued, was transferred to the Cleveland office as district manager and the Buffalo district was incorporated in the Cleveland office territory. **S. A. Sargent,** former district representative of the New England territory, was transferred to the Chicago district office.

Thomas W. Lloyd was appointed as district superintendent of the Harbison-Walker Refractories Company works at Baltimore, Maryland, and Chester, Pennsylvania. **A. M. Tvergaard** has been named superintendent of the new Baltimore plant which is scheduled for completion in early fall. Mr. Lloyd first became associated with Harbison-Walker in 1929 at the East Chicago works, and occupied successive positions at the Portsmouth, Ohio, and Kentucky works until 1937 when he


Modern Sawing
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KLING HIGH SPEED FRICTION SAWS
24" 100-lb. I Beam 28 Seconds
15" 55 lb. Channel 15 Seconds
8" x 8" x 34.3-lb H Beam 10 Seconds
9 Seconds 100-lb. A.R.A. Rail
5 Seconds 6½" x 6½" x 19.8 lb. Tee
11 Seconds 8" x 8" x ¾" Angle
10 Seconds 3" Square
15 Seconds 4" Round
11 Seconds 6" O.D. Tube ½" Wall

Friction sawing is one of few mechanical processes which employ the heat of friction in a useful manner. It concentrates heat on the material to be severed at a rate which is faster than it can absorb heat. The immediate temperature rise of the contact surface is so great that its strength is reduced considerably lower than that of the colder blade rim. This heated surface is readily removed by the blade and permits complete severing of the material rapidly with no loss of metal from the blade.

Because of its versatile ability to cut many varied structural shapes, as well as solid or hollow bars in any sequence, without change of blade or setup, one machine can handle a volume of cutting that would otherwise require several separate shears or slow speed saws.

Consult Kling engineers regarding your metal cutting problems. State size of material to be cut. Bulletin No. 9200 giving full particulars and suggestions as to the type and size of saw will be mailed promptly. No obligation.

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Punches; Bar, Angle and Rotary Shears; Combination Shear, Punch and Copers; Plate and Angle Bending Rolls; Heavy Duty Grinders

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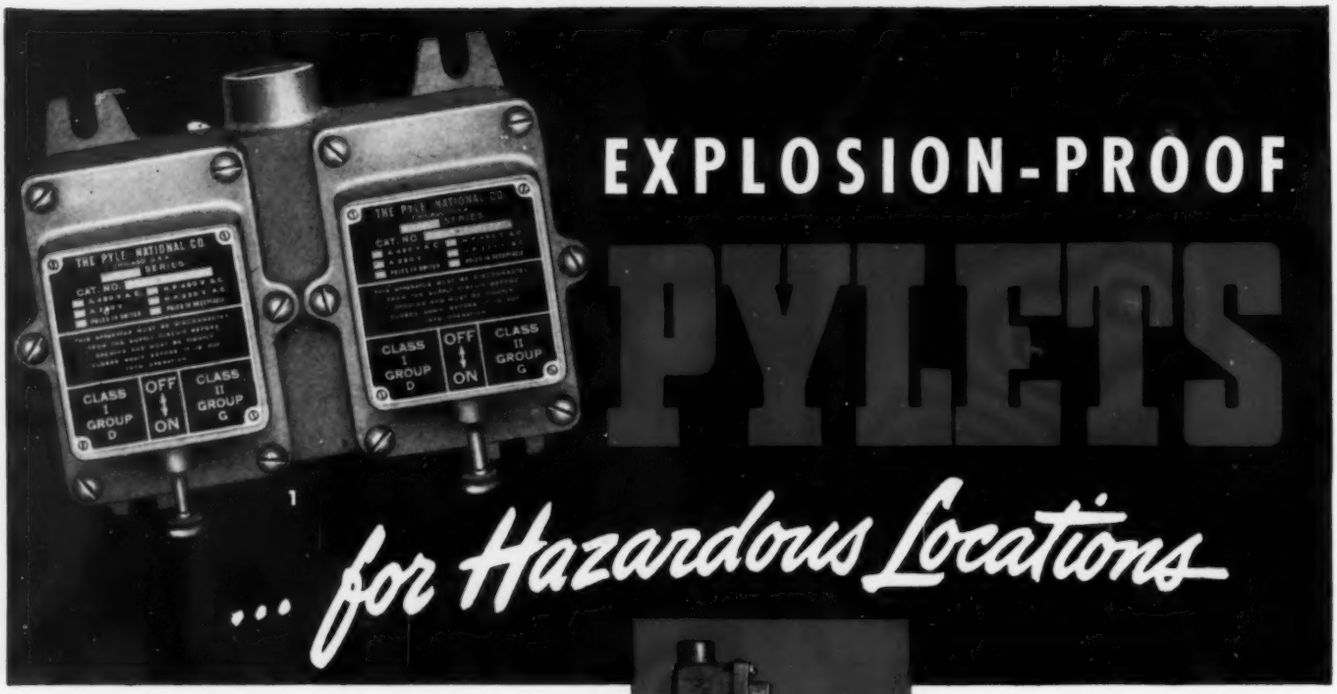

EXPLOSION-PROOF SWITCH PYLETS

1. *TUMBLER SWITCHES with push-pull Rod*
to control motors or lighting circuits in hazardous locations. 1 and 2 gang, 1, 2 and 3-pole, 10 to 30 ampere, also 3 way and 4 way, 10 and 20 ampere types.

2. *TUMBLER SWITCHES with interlocking Plug*
Receptacle for use as service outlets for portable electrical equipment in hazardous locations. Plugs cannot be inserted or withdrawn unless switch is open. Switch cannot be closed unless plug is fully inserted. 2 and 3-pole, 20 and 30 ampere, 250 and 460 volt ratings.

3. EXPLOSION-PROOF SECONDARY CIRCUIT BREAKER PYLETS for protection of motors against overloads and stalled rotor currents. Can also be used for "on" and "off" switch. Single and double pole with a selection of interchangeable heater units for protecting fractional horsepower motors.

4. EXPLOSION-PROOF UNIVERSAL JUNCTION PYLETS—6, 7 and 10 hub types with close-up plugs. For easy replacement of sheet metal knockout boxes in the rewiring of old gasoline pump installations.

5. EXPLOSION-PROOF JUNCTION PYLETS available in a wide selection of styles and sizes with threaded or union type hub. Furnished with plain covers for general use or with covers tapped for conduit to support lighting fixtures. Also furnished with pipe plug angle type cover for filling with sealing cement.

6. PYLE-O-FLEX flexible explosion-proof and watertight fittings for adjustable and vibrative connections to motors, floodlights and pendant type lighting fixtures. Furnished in any combination of male and female threaded or female union type end connections with flexible lengths of 4 to 36 inches, conduit sizes ½" to 2" inclusive.

7. EXPLOSION-PROOF SEALING PYLETS have removable pipe plug covers which can be mounted in any one of four positions for filling with cement. Used to isolate the wiring compartments of arc-producing devices from balance of conduit system.

EXPLOSION-PROOF UNIONS, male and female, straight and 90° elbow types.

A line of the most commonly used types of conduit fittings for hazardous locations as defined in Article 500 of The National Electrical Code. Explosion-proof Pylets are designed in accordance with Underwriters' Laboratories requirements and are classified in their list of inspected electrical appliances. Their substantial construction and the high quality of materials and workmanship insure safety, uninterrupted service and long life. Consult your Pylet Catalog 1100 for complete listings of the above and other Explosion-Proof and Dust-Tight Pylets.

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resumed his studies in industrial engineering at Ohio State University. Shortly after receiving his degree in 1939, he came to Pittsburgh to join the engineering department of Harbison-Walker. In January, 1941, he was transferred to Chester as assistant superintendent of that plant. He has been superintendent of the Baltimore works since 1947.

August C. Jacob, assistant superintendent of maintenance in the Youngstown district of Youngstown Sheet and Tube Company, retired June 30 after 46 years of service. Mr. Jacob joined the company August 20, 1901, as a rigger helper, became a rigger three years later, general rigger foreman in 1913, master mechanic of the steel department in 1917 and assistant superintendent of maintenance in 1940. After a rest at home he may do some traveling.

John Bruce Carlock was named as chief consulting engineer for Loftus Engineering Corporation. Mr. Carlock is retiring from the active steel production field as chief engineer of plants for the Jones and Laughlin Steel

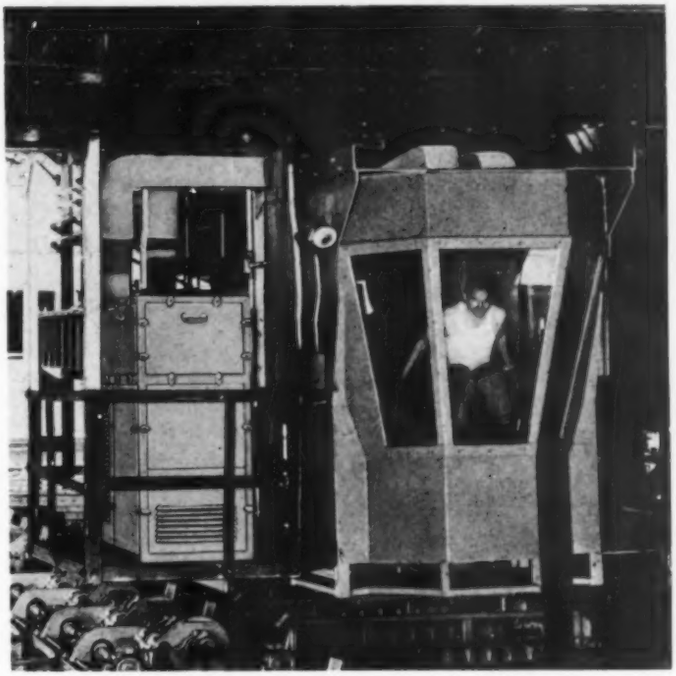
JOHN BRUCE CARLOCK

Corporation. His activities with the Loftus Engineering Corporation will be devoted to the design and construction of industrial plants and their related facilities for the iron and steel industry.

J. H. Lammert has recently been elected vice president of Oliver Iron and Steel Corporation, Pittsburgh. Mr. Lammert joined Oliver in 1905 as a messenger. He has served in the mailing, sales, order entry and purchasing departments, and will continue as general purchasing agent to which position he was appointed in 1935. **Hugh A. Dewar** has been named a district sales manager of the pole line hardware sales division, in Los Angeles, succeeding **John A. Duncan,** who has retired.

Paul H. Startzman was named general manager in charge of operations at Oliver Iron and Steel Corporation, effective August 2. Mr. Startzman is resigning from his partnership in the firm of Drake, Startzman, Sheahan, Barclay, Incorporated, New York engineering specialists in material handling and allied industrial operations.

Davis D. Cox has been appointed superintendent of the By-Products Coke department, Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama, succeeding **John J. Phillips,** who has retired after more



Soaking Pit Crane in Plant of a prominent steel company, equipped with Lintern Aire-Rectifier 145 AC-24.

The Only Crane Cab Conditioner Thoroughly Tested on Soaking Pit Applications

● In the illustration above the Lintern Aire-Rectifier was tested on the particular crane shown. It is the center crane of three.

After thorough testing, the plant installed Lintern Aire-Rectifiers on the other two cranes. All three gave satisfactory performance thoughout the past hot summer.

Lintern balanced refrigeration design prevents overloads in temperature as high as 170° F. This is the only crane cab conditioner which has had thorough testing on soaking pit applications. It is tried and proved. Only periodic inspection is required.

Ask for Bulletin AC 82147 describing the four new models now available for all types of mill and industrial cranes.

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Glowlite Signals, Lanterns, Sanders, Shock Absorbers for Lamps, Ventilating Heaters, Aire-Rectifiers for Overhead Cranes

Everything in steel plant piping . . . from the complete Crane line

ONE
SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY

This tin mill, for example, shows how far the Crane line goes to help you standardize on quality piping—and to simplify all piping procedures.

Here's **one source of supply** for all your piping needs—assuring you truly complete selection of the best in valves, fittings, accessories, pipe, and fabricated piping. One catalog and one order cover everything for the job—in iron, steel, brass, and alloy materials.

Making Crane **solely responsible** for piping equipment helps you to get better installation in your plant, and to avoid needless delays. The **uniform high quality** of all equipment from Crane secures—as it has for more than 90 years—the most efficient and dependable operation of piping systems from end to end.

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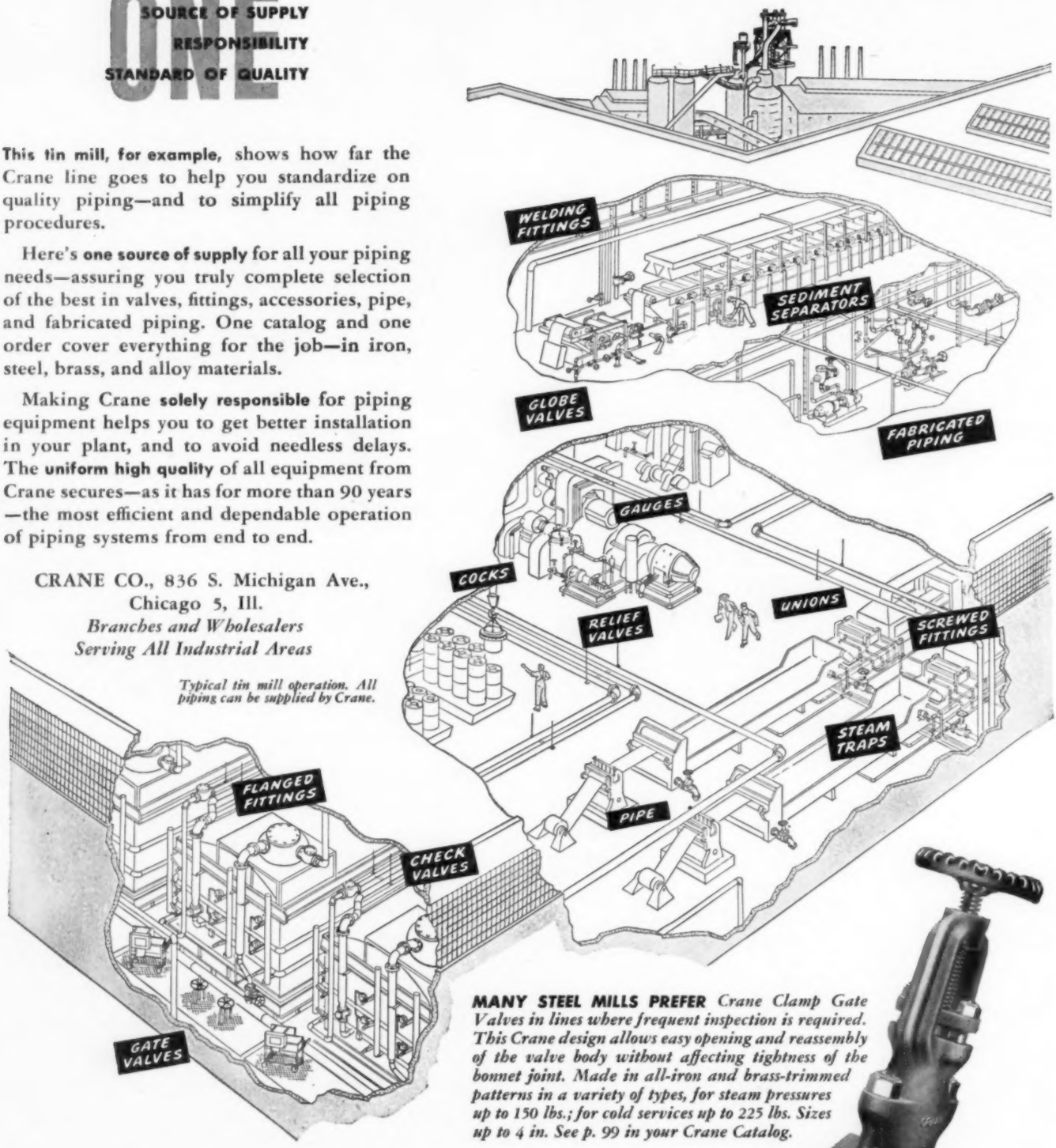
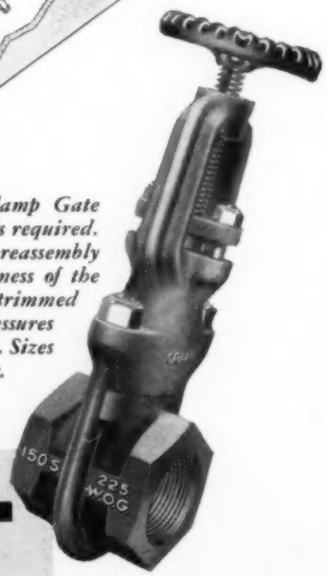
Serving All Industrial Areas



Typical tin mill operation. All piping can be supplied by Crane.



MANY STEEL MILLS PREFER *Crane Clamp Gate Valves in lines where frequent inspection is required. This Crane design allows easy opening and reassembly of the valve body without affecting tightness of the bonnet joint. Made in all-iron and brass-trimmed patterns in a variety of types, for steam pressures up to 150 lbs.; for cold services up to 225 lbs. Sizes up to 4 in. See p. 99 in your Crane Catalog.*

EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

than 40 years with the company. **Oscar H. Wilson** has been named assistant superintendent of that department, succeeding Mr. Cox and **David P. McMillan,** superintendent of ovens and unloading station, succeeding Mr. Wilson.

W. F. Huntley was appointed as assistant to superintendent of blast furnace department of the Aliquippa, Pennsylvania, works of Jones and Laughlin Steel Corporation.

R. E. Edwards has been appointed assistant to superintendent of open hearth and bessemer department, Jones and Laughlin Steel Corporation, Aliquippa, Pennsylvania.

A. B. Millman was named assistant to superintendent of maintenance, Jones and Laughlin Steel Corporation, Aliquippa, Pennsylvania.

C. F. Seyler, formerly assistant chief engineer of plants, was appointed assistant chief engineer for Jones & Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

H. P. Saxer has been named superintendent of the blast furnace department, Pittsburgh works, Jones and Laughlin Steel Corporation, and **J. R. McCarney** has been appointed assistant to the superintendent.

E. J. LeViseur was named superintendent of maintenance, Pittsburgh works, Jones and Laughlin Steel Corporation.

J. M. Morris has been appointed general maintenance engineer at Pittsburgh works of Jones and Laughlin Steel Corporation.

Ralph S. Drummond was appointed as manager of the Cincinnati Crocker-Wheeler branch office. Mr.

RALPH S. DRUMMOND

Drummond comes to Crocker-Wheeler from the Dynamotor Corporation, where he was sales manager.

Barney N. Dagan of Ontario, California, has been named superintendent of the open hearth department at the steel plant of Kaiser Company, Inc., Fontana, California. Mr. Dagan, who has been with the Kaiser organization since July 1, 1946, was promoted from the position of assistant open hearth superintendent, and is a graduate of Ohio State University, with a degree in chemical engineering. During the war he was a lieutenant in the U. S. Navy, and before that he was connected with Youngstown Sheet and Tube Company of Ohio from 1937 until 1943.

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- **YOUR PRESSURE LOSS**
- **THE CONDITION OF YOUR WATER AND SEWAGE PIPES**

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ENGINEERING SURVEY
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  An engineering survey of your complete piping system.
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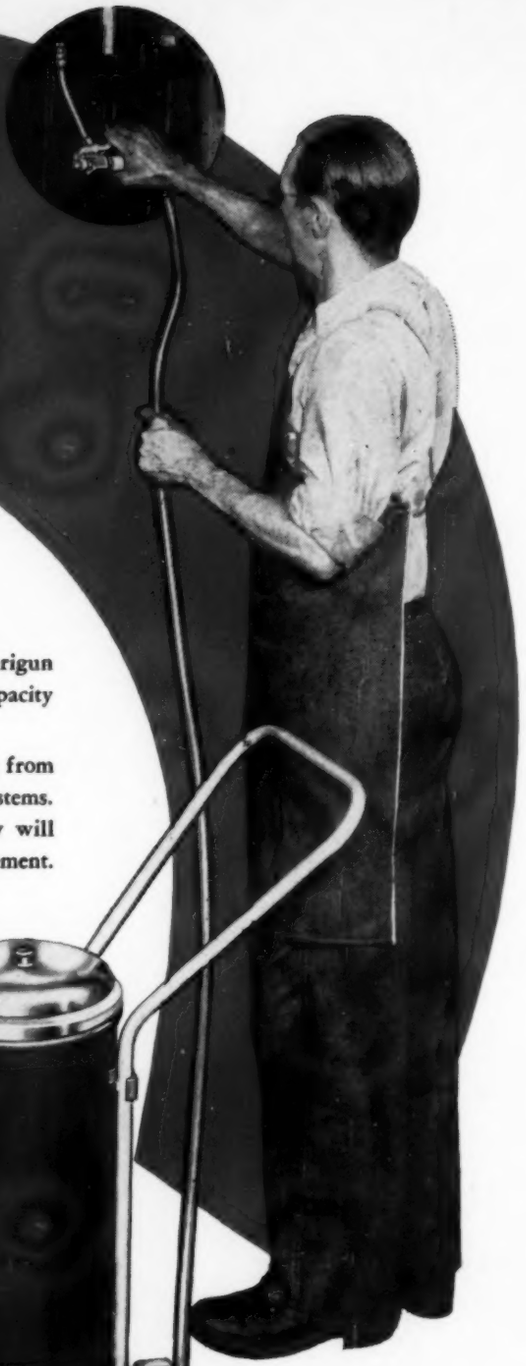
Save 15 to 20% in Lubrication Time



For fast, easy, positive lubrication — it's hard to beat the portable Lincoln Electric Lubrigun. It does away with older, time-consuming methods of hand lubrication and increases the output of your machines by boosting their productive capacity. The Lincoln Electric Lubrigun delivers lubricant under high pressure from a large 30-lb. capacity container.

Lincoln can fill your lubricating equipment needs—everything from grease fittings to complete automatic centralized lubricating systems. Your industrial distributor, or any of the offices listed below will gladly show you the complete line of Lincoln Lubricating Equipment.

LINCOLN
Electric
LUBRIGUN
(PORTABLE)

Model 244

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BOSTON—H. G. Davis, Inc.—Kenmore 5176
BRIDGEPORT—H. G. Davis, Inc.—Bridgeport 5-8160
CHICAGO—Lincoln Engineering Co., of Ill.—Calumet 6022
CLEVELAND—Lincoln Lubricating Systems, Inc.—Express 4334
DETROIT—Lincoln Engineering Co.—Madison 3484
EAST ORANGE—Lincoln Lubricating Systems, Inc.—Orange 3-3188
LOS ANGELES—Lincoln Engineering Co., of Calif.—Richmond 0151
NEW YORK—Lincoln Lubricating Systems, Inc.—Trafalgar 7-7900
OAKLAND—Lincoln Engineering Co., of Calif.—Higate 6130
PITTSBURGH—Lincoln Engineering Co.—Montrose 1444

- *APPLY THE RIGHT LUBRICANT*
- *IN THE RIGHT QUANTITY*
- *AT THE RIGHT TIME*

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Robert Kyle has recently joined Gas Machinery Company, Cleveland, Ohio, as gas sales engineer. A graduate gas engineer of Johns Hopkins University, he received early training at the Consolidated Gas, Electric Light and Power Company of Baltimore and at the American Gas Association Laboratories in Cleveland.

Mr. Kyle was formerly with the General Controls Company as branch manager of the Cleveland office; prior to that with the Iroquois Gas Corporation, Buffalo, New York, as gas engineer.

Ross C. Cornish, general consulting engineer, has joined Gas Machinery Company, Cleveland, Ohio, as consulting engineer. Mr. Cornish has been connected with the gas business for over fifty years. For 16 years he was chief engineer of The American Gas Company in charge of engineering and operation of gas and electric plants. After the purchase of American Gas Company by United Gas Improvement Company, he was assistant to the vice president in charge of engineering development. Mr. Cornish later was chief engineer of Semet-Solvay Engineering Corporation.

Paul E. Thomas was appointed chief engineer of Gary Steel works of Carnegie-Illinois Steel Corporation. He succeeds **J. Donald Rollins** who has been promoted to become planning engineer of Carnegie-Illinois with headquarters in Pittsburgh. For the last year Mr. Thomas has been serving as assistant division superintendent of maintenance at the Gary plant. He is a native of Swayzee, Indiana, a graduate of Windfall, Indiana high school and received his electrical engineering degree from Purdue University in 1927. He has been associated with United States Steel and subsidiaries since 1920. He first worked at the plant of the former American Sheet and Tin Plate Company in Elwood, Indiana. He has been at Gary works since 1924 except for a leave of absence to complete his education at Purdue.

PAUL E. THOMAS

Mr. Rollins has been with United States Steel subsidiaries since 1934. He became associated with Carnegie-Illinois in 1936 and has been with the Gary organization for the last 11 years.

J. S. Ferguson, general superintendent of the Hamilton plant of Armco Steel Corporation, has been appointed technical director of the Argentine Steel Division of the Armco International Corporation. He will depart

Steel Mill Switches Fuels as Much as 10 Times a Day

Yet Their

HAUCK *Combination* **Oil and Gas BURNERS**

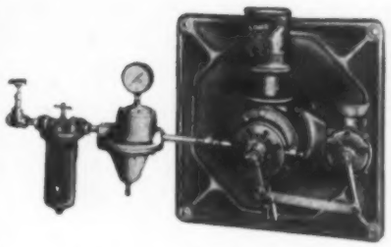
ALWAYS REMAIN EQUALLY EFFICIENT

When the supply of natural gas runs low, they switch to oil and run just as smoothly until a new gas supply is available, changing from one fuel to the other as necessary.

Once burners are adjusted for burning either oil or gas, the change from oil to gas or vice versa can be made quickly by merely closing one fuel shut-off valve and opening the other, without piping changes.

One control lever regulates and proportions the flow of air through the burner and at the same time the flow of oil or gas, or both fuels when so adjusted.

These burners are easy to install and operate on any furnace. They really meet the emergency of today's fuel pinch.



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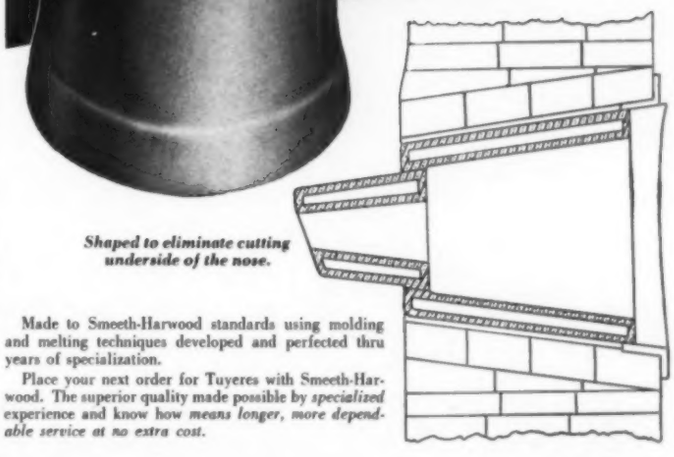
Steudel Blast Furnace **TUYERES** by SMEETH-HARWOOD



Shaped to eliminate cutting underside of the nose.

Made to Smeeth-Harwood standards using molding and melting techniques developed and perfected thru years of specialization.

Place your next order for Tuyeres with Smeeth-Harwood. The superior quality made possible by *specialized* experience and know how *means longer, more dependable service at no extra cost.*

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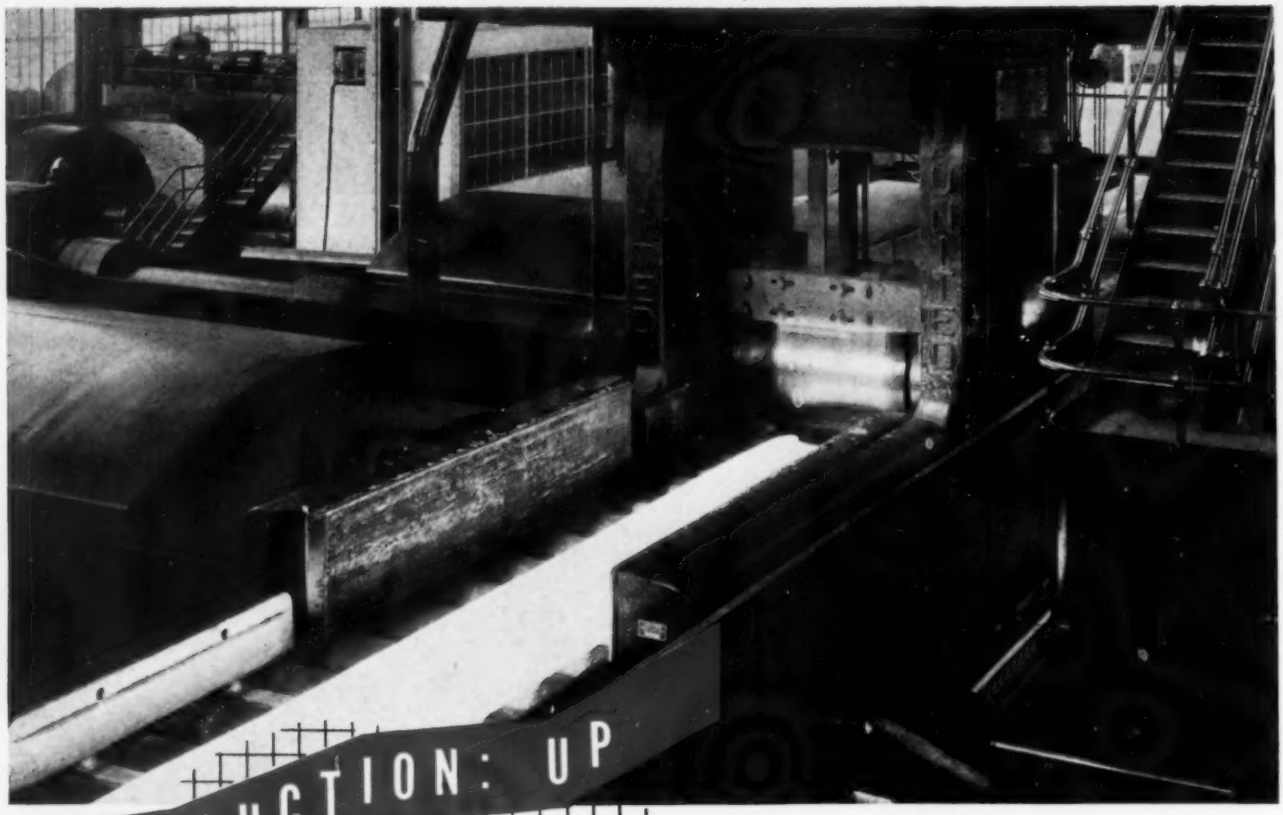
Superior **Blast Furnace Copper Castings** ***Exclusively.***



PRODUCTION: UP
COSTS: DOWN

with A-B-K Laminated Plastic Bearings

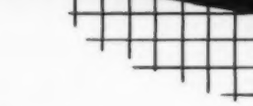
● On all types of steel mill operations, A-B-K Laminated Plastic Bearings have proved their ability to support peak production—*and cut costs.*

Tough, resilient A-B-K Bearings actually *outwear metal.* They resist heat, acids and alkalies—will not distort under shock. And they hold gauge longer . . . reduce shutdowns for adjustments and replacements.

In addition, A-B-K Bearings are water-lubricated—require no oil or grease. Their ideal coefficient of friction reduces power consumption.

It will pay you to see how these advantages of A-B-K Laminated Plastic Bearings can be applied in your mill. An A-B-K representative will call with the full facts in response to your letter, wire or telephone call.

A-B-K slipper bearing with patented reinforced edge.



Phantom view of slipper bearing.

A-B-K roller neck bearing with separate collar.

AMERICAN Brake Shoe COMPANY

AMERICAN BRAKEBLOK DIVISION
DETROIT 9 MICHIGAN

A-B-K
Laminated Plastic Bearings

for the Argentine shortly where he will serve as liaison officer with the companies which will build a large completely integrated steel plant at San Nicolas on the Parana River. Mr. Ferguson will make his headquarters in Buenos Aires.

The government of the Argentine and private interests of that country are joining in a gigantic venture through which it will be possible to produce much of the country's steel requirements. A contract has been made with The Armco International Corporation to supply technical steelmaking and engineering knowledge and consultation in connection with plant operations.

The plant will consist of modern coke ovens, a by-products plant, a large blast furnace, open hearths, a blooming mill, structural and rail mill, a modern strip mill and a tin plate plant.

L. S. Cope has been made head of research and product engineering at Oliver Iron and Steel Corporation, in a move which marks the beginning of an expanded product development program by the corporation. Formerly general manager in charge of production, Mr. Cope has assumed his new duties on his return from an extended leave of absence. He will assume technical direction of die and tool engineering, metallurgical and special mechanical engineering and product development in his new capacity.

We asked a few Operators how they are doing with

ANGLE FLOW TUYERES

U. S. Pat. 2,124,437

Tuyere at top-center of illustration is Angle Flow type with refractory nose.

Here's What They Reported . . .

Increased requests for the Angle Flow Tuyere, both with and without refractory nose, prompted us to check current results with angle flow installations. These operators enthusiastically reported greatly improved conditions, reduced burning after a switch to Angle Flow Tuyeres.

With tuyere pointed down (towards six o'clock) one operator reports his tuyere life increased from 24 days on conventional type to 100 days with refractory nose Angle Flow Tuyeres. Another who was getting from 30 to 35 days on a conventional type had had Angle Flow units with refractory nose in operation for 60 days and they still remained in the furnace. A third operator stated that he had been burning certain tuyeres nearly every day and that Angle Flow Tuyeres had apparently corrected this condition.

Other reports equally favored Angle Flow Tuyeres. There is every indication that this tuyere design, in Falcon quality casting, is capable of eliminating many troublesome, costly burning problems. Certainly they warrant a trial installation. Falcon is licensed to produce the Angle Flow Tuyere under U. S. Pat. No. 2,124,437 and is prepared to offer prompt delivery.

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YOUNGSTOWN 3, OHIO

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LOOK TO THE FUSE LEADER FOR PRODUCTION PROGRESS

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WARE HI-LAG *Renewable* FUSES

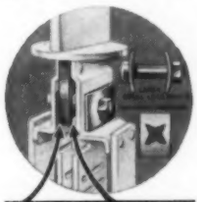
Cool Facts No. 3

NON-HEATING CONTACTS

The wide contact surface maintains low contact resistance.

Spring tension on links locked into position, prevents loosening of contacts, which causes over heating.

Connections held firm by large arched spring steel washers and heavy bolts.



LINKS LOCKED IN TO CIRCUIT

APPROVED BY UNDERWRITERS' LABORATORIES

The Fuse That Prevents Excessive Heating and Needless Blowouts — Gives 100% Protection

End once and for all times the unnecessary delays—shut downs — interruptions and costly expense resulting from out-of-date fuses.

Modern science has developed the coolest operating fuse in the WARE HI-LAG—the SAFE—ECONOMICAL and FOOLPROOF Fuse, giving greatest satisfaction and service with full protection.

The reasons for WARE HI-LAC Super Performance are —higher lag for starting loads and surges—greater strength and durability—link designed for maintaining low resistance—non-heating, spring tension contacts with greater contact area. These are features which save time, expense and renewal costs. Start economizing! Try WARE HI-LAG Today!

Write for Fuse Booklet No. 4460 giving all features, sizes and details.

WARE FUSE CORPORATION

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Why tolerate this visible evidence of high lubrication and application costs? There's a special grade of dripless, wasteproof NON-FLUID OIL for every type of overhead crane motor. Write today for instructive bulletin and free, testing sample of NON-FLUID OIL. See for yourself how NON-FLUID OIL gives *clean* lubrication and *clean* products at lower cost.

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NON-FLUID OIL is not the name of a general class of lubricants, but is a specific product of our manufacture.

NON-FLUID OIL
TRADE MARK REGISTERED

Obituaries

Frank F. Marquard, 73, former general superintendent of the Carnegie-Illinois Steel Corporation's Clairton Works, died unexpectedly of a heart attack on July 26.

After a steel industry career in which he became widely known for his discoveries in the field of metallurgical chemistry, Mr. Marquard retired on January 1, 1944, after more than 45 years of continuous service with United States Steel subsidiaries.

Birger Gustaf Thele, chief engineer of the coal mining department at Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama, died recently. Mr. Thele was born in Stockholm, Sweden, April 18, 1899.

BIRGER GUSTAF THELE

He received his engineering degree at Orebro, Sweden. He came to America in 1920.

For many years, Mr. Thele acted as secretary of the Birmingham district section of the Association of Iron and Steel Engineers.

Harry G. Lewis, president of Electric Service Manufacturing Company, Philadelphia, Pennsylvania, died on July 15. Mr. Lewis was born in England in 1876. He came to this country at an early age, and spent most of his business life with the company. He had been president since April, 1945.

L. H. Underwood, 67, assistant to the vice president in charge of operations for Youngstown Sheet and Tube Company, died in Youngstown, Ohio, June 26. Mr. Underwood, a native of Dixon, Illinois, entered Massachusetts Institute of Technology to study civil engineering, but two years later changed to mining and metallurgy. Following his graduation he joined the blast furnace department of National Tube Company at Benwood, West Virginia, and three years later was appointed superintendent, a post he held six years. From Benwood he transferred to Gary works of Illinois Steel Company to learn the by-product coke business and was there three years. In 1915 he joined Youngstown Sheet and Tube Company as superintendent of the coke plant then being built at Youngstown and held this position five years. He then joined an independent company in Chicago but a year later returned to Illinois Steel as assistant superintendent of blast furnaces. In 1925 Mr. Underwood rejoined Youngstown Sheet and Tube Company as superintendent of blast furnaces at Indiana Harbor. Later that year he also was made superintendent of the coke plant. In 1929 he was made general superintendent of the Chicago district and one year later was made manager of Chicago district properties. Thirteen years ago Mr. Underwood was transferred to general offices in Youngstown as assistant to the vice president in charge of operations. He supervised the company's coal mining properties.

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Many of the leading industrial organizations who are already using this service exclusively, say it is the answer to their pipe cleaning problems. Case histories and names will be furnished upon request.

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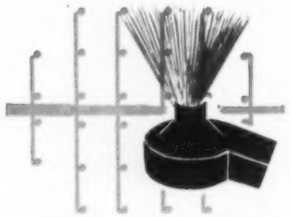

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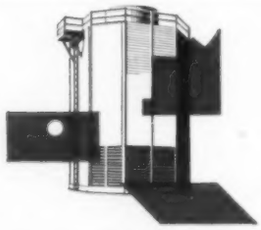
TRUE "COUNTERFLOW"...



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DATE LINE DIARY...

July 1

▲ The Aluminum Company of America has raised the price of several grades of aluminum one cent. This increase now makes 10,000-lb 99+ per cent aluminum 16¢ a pound, and pig aluminum is now 15¢ a pound.

▲ The Westinghouse Electric Corporation announced wage increases ranging from 9 to 16¢ per hour for 70,000 production and salaried employees. Increases are retroactive to June 11.

July 2

▲ The International Nickel Company of Canada, Limited, announced today that by agreement between the U. S. Department of Justice and the companies the anti-trust proceedings against The International Nickel Company of Canada, Limited, and its United States subsidiaries have been terminated by the entry of a final judgment, without trial and without any finding that the company has violated any law.

▲ The several steel companies which operate coal mines of their own filed today with the general counsel of the NLRB a charge of unfair labor practice against the United Mine Workers of America on the ground that the unqualified union shop provision which that union insists must be included in the new labor contracts applicable to the captive coal mine operators is in violation of the Taft-Hartley Act.

July 3

▲ Domestic freight cars delivered during June totaled 10,387. Thus for the first time the 10,000-car monthly goal was achieved.

July 4

▲ The Westinghouse Electric Corporation announced that, due to increased production costs, prices on some industrial and power equipment are being raised above five per cent. This equipment includes large electric motors, engine-driven generators, motor-generator sets, gear motors, and various items of switchgear apparatus. Prices of standard control equipment have been increased 10 per cent.

July 5

▲ The Allis-Chalmers Manufacturing Company announced an 8 per cent wage increase today, which amounts to 15¢ per hour for some 33,000 employees.

July 6

▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 90.3 per cent of capacity for the week beginning July 6, 1948. This is equivalent to 1,627,600 tons of steel ingots and castings, compared with 1,716,000 tons one week ago. The decline in the operating rate this week reflects the effect of the Independence Day holiday and the coal miners' strike, which closed some beehive coke ovens.

July 7

▲ Tomlison Fort, manager of central station sales for Westinghouse Electric Corporation, in a recent speech stated that there would be an increase in electric power sold in the United States from 217 billion kilowatt hours in 1947 to 374 billion kilowatt hours in 1957. Generating facilities for the country must be expanded more than 80 per cent to carry this greatly increased load. He also stated that the power situation today is serious and that reserve capacities in the generating stations in this country were only 5 per cent in 1947.

July 8

▲ Benjamin F. Fairless, president of United States Steel Corporation, announced today that in the near future the steel-producing subsidiaries of United States Steel Corporation will adopt the method of announcing prices of steel products at the mill or shipping point or, if the customer so desires, at delivered prices which reflect full transportation charges from shipping point to destination. This decision follows a ruling of the Supreme Court of the United States in the proceeding brought by the Federal Trade Commission against the members of the cement industry. This announcement was followed by announcements from most of the other steel companies.

July 9

▲ Pittsburgh Steel Company announced that, effective July 6, it had increased prices on oil country tubular goods about $30 a ton.

July 10

▲ Robert W. Wolcott, president of Lukens Steel Company, has been requested by the Secretary of Commerce to see what can be done to eliminate the remaining obstacles which stand in the way of shipping scrap from Germany to the United States.

July 11

▲ The total payroll of the iron and steel industry in the first five months of 1948 was $874,576,000, an increase of 10.5 per cent over the corresponding months of 1947. Average hourly earnings of wage workers in May were $1.577, compared with 11.551 in April. Employment in May was estimated at 627,600 persons.

July 12

▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 90.8 per cent of capacity for the week beginning July 12. This is equivalent to 1,636,600 tons of steel ingots and castings, compared with 1,627,600 tons one week ago.

▲ Five refrigeration equipment manufacturers, all members of the Frozen Food Institute, bought the Sterling Steel Foundry Company of Pittsburgh, thus transferring another steel-producing facility into the hands of steel consumers. An expansion program is contemplated which will increase the company's ingot capacity to about 8000 tons a month.

▲ According to the Lake Superior Iron Ore Association, movement of Lake Superior ore for the season up to July 1 totaled 31,013,896 gross tons. Based on the movement so far, it is estimated that approximately 83 million tons will be moved.

▲ The Carnegie-Illinois Steel Corporation, The National Tube Company, and the American Steel & Wire Company announced today new mill prices on their products which are based on the change from the old basing point method. These prices reflected no change from present basing point prices, and become effective with shipments made July 13.

July 14

▲ The National Bituminous Coal Advisory Council estimated in a report that steel requirements of domestic bituminous coal industry are 682,900 tons annually. This amount of steel or more must be made available to the mining and mining equipment industries if production of coal in adequate quantities is not to be hampered. This estimate is based on an output of 620 million tons of bituminous coal a year. The greatest single use of steel in coal mines is for track.

July 16

▲ Benjamin F. Fairless, President of the United States Steel Corporation, announced today that wage increases, averaging approximately 13¢ an hour, or about 9 per cent, are being granted to steel workers. Thus the United States Steel Corporation gave up the fight which it had led against inflation when it reduced prices and denied wage increases to its steel workers last April. One factor tied in with the wage increase announcement was a statement that price increases of products would soon be forthcoming. This wage increase was followed by most of the other steel companies.

July 19

▲ Lukens Steel Company announced price increases of $6 a ton on carbon and alloy steel plates.

▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 93.1 per cent of capacity for the week beginning July 19. This is equivalent to 1,678,000 tons of steel ingots and castings, compared with 1,636,600 tons one week ago.

July 20

▲ Benjamin F. Fairless, President of United States Steel Corporation, announced today that new prices at mills or shipping points will become effective July 21, 1948. These new prices embrace a restoration of the average price reduction of about $1.25 a ton made last April and included in addition an average increase of about $8.09 in the major steel products quoted by the United States Steel subsidiaries. These new prices reflect increasing freight costs, material costs, and the wage boosts announced the previous week. These boosts were subsequently followed by increases by a number of other steel producers.

July 21

▲ A report issued by Dun and Bradstreet today showed that failures among manufacturers, wholesalers, and retailers in food products had increased about one-fifth for the first 5 months of 1948 over the corresponding period of 1939. Total number of failures was 108, with an average liability of $178,000 per failure.

July 22

▲ Carnegie-Illinois Steel Corporation and American Steel and Wire Company announced new mill prices on pig iron. Basic pig is now $43 per gross ton at the mill, and Bessemer is now $44 per gross ton.

July 23

▲ General Electric Company announced today price readjustments in integral horsepower induction motors. Changes vary as much as 20 per cent, either up or down, although there is no general increase in the overall price level.

▲ The Hanna Furnace Corporation announced today that the new mill price on basic pig iron is $44 per ton.

▲ The Youngstown Sheet and Tube Company announced today that approximately 21,000 present employees, as well as several thousand former employees, will share in a $4 million wage adjustment distribution.

July 25

▲ American Iron and Steel Institute announced today that production of stainless and heat resisting steels has increased from 180,000 tons in 1938 to 520,000 ingot tons in 1947. In 1947 stainless steel finished production set a record of 333,000 tons.

July 26

▲ American Iron and Steel Institute announced today that in 1947 more than 2 billion gallons of fuel oil, or 28 of every 1000 barrels produced in the United States, were consumed by the iron and steel industry. Coal used by the industry was 94,272,000 net tons, which constituted 14 per cent of all the anthracite and bituminous coal mined last year. The steel industry consumed 21 billion kilowatt hours of electricity. Iron and steel companies also used 255 billion cubic feet of natural gas in 1947, or 13.8 per cent over 1946. About 6,369,000 net tons of fluxes were used in furnaces, and 266,114,233 gallons of tar and pitch were consumed.

▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 93.1 per cent of capacity for the week beginning July 26. This is equivalent to 1,678,100 tons of steel ingots and castings, compared with 1,678,100 tons one week ago.

July 27

▲ Estimated total booking of fabricated structural steel, according to the American Institute of Steel Construction were 158,270 tons, or 15 per cent greater than the bookings for the preceding month.

July 29

▲ According to Dun and Bradstreet, of the $5.3 billion European Recovery Program, $1,324,300,000 worth of American and other Western Hemisphere products will be shipped to the United Kingdom. France will receive $1,130,800,000, while Italy will receive $703,600,000. Fifty-four per cent of the money will be spent on U. S. products. The program includes $75.5 million of finished steel and $43.3 millions of electrical equipment.

▲ Significant in the new f.o.b. steel price system is the announcement that the Kelsey-Hayes Wheel Company of Detroit, Michigan, will extend its operations into the Pittsburgh district. A portion of the McKeesport Works of Jones and Laughlin Steel Corporation was sold to the fabricator, which is one of the principal manufacturers of automobile wheels and rims.

July 30

▲ United States Steel Corporation announced today that income for the first six months of 1948 was $66,543,018, compared with $68,571,379 in 1947. Shipments by the corporation of steel products for the first six months of 1948 were 10,213,689 net tons, compared with 10,132,390 net tons shipped during the first six months of 1947.

▲ Comparing steel company earnings for the first half of 1948, they show only slight changes from the corresponding period of 1947, although sales and costs are both up.

▲ The American Iron and Steel Institute announced that average hourly earnings of steel production works in 1947 rose 78 per cent over those of 1940. Iron and steel industry dividends rose only 34 per cent in the corresponding period. Dividends in 1947 were $193,900,000, whereas Federal income taxes for 1947 were nearly $300,000,000.

▲ Steel production in the Ruhr hit a new postwar high in June, 1948, increasing 71 per cent above June, 1947, to 377,750 metric tons.

▲ The Bethlehem Steel Company announced some price reductions of $1 to $3 per ton. This follows the general price markup of the previous week and reflects corrections in selected items to maintain its competitive position.

▲ Reflecting price increases is STEEL'S price composite, and the arithmetical average on finished steel rose to $89.09 for the final two weeks of July, compared with $80.27 at the beginning of the month.

INCO OFFERS EXPERIENCED COUNSEL ON METAL PROBLEMS

Avail yourself of experienced counsel on problems relating to the properties, treatment, fabrication or performance of ferrous and non-ferrous metals containing nickel.

We offer consultation . . . and invite you to write, wire or phone the INCO Technical Field Section or Stock and Service Center nearest to your plant.

"INCO" TECHNICAL SECTIONS

Consultation on technical problems relating to alloys containing nickel is invited. Consult the nearest Technical Field Section of INCO Development and Research Division listed below:

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25 King Street, West,
Toronto 1, Ont.
Tel. Elgin 7471

CENTRAL ATLANTIC COAST SECTION
67 Wall Street,
New York 5, N. Y.
Tel. Whitehall 4-1000

CHICAGO SECTION
333 N. Michigan Avenue,
Chicago 1, Ill.
Tel. Franklin 4030

CINCINNATI SECTION
Carew Tower,
Cincinnati 2, Ohio
Tel. Parkway 1632

DETROIT SECTION
General Motors Building,
Detroit 2, Mich.
Tel. Madison 3436

EMPIRE STATE SECTION
Genesee Valley Trust Bldg.,
Rochester 4, N. Y.
Tel. Main 2393

NEW ENGLAND SECTION
75 Pearl Street,
Hartford 3, Conn.
Tel. Hartford 7-0383

PITTSBURGH SECTION
Grant Building,
Pittsburgh 19, Pa.
Tel. Atlantic 9546

ST. LOUIS SECTION
Ambassador Bldg.,
St. Louis 1, Mo.
Tel. Garfield 4197

TEXAS SECTION
Commerce Bldg.
Houston 2, Texas
Tel. Charter 4-4234

TWIN CITIES SECTION
Northwestern Bank Bldg.,
Minneapolis 2, Minn.
Tel. Geneva 0631

WEST COAST SECTION
Petroleum Bldg.,
Los Angeles 15, Calif.
Tel. Prospect 2496

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The following are sources of supply for primary nickel for alloying purposes. Through casting specialists, they are prepared to offer technical service on the production of ferrous and non-ferrous castings containing nickel.

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J. M. Tull Metal & Supply Co.
285 Marietta Street
Tel. Walnut 3525

BALTIMORE 17
Whitehead Metal Products Company, Inc.
413 West North Avenue
Tel. Lafayette 2300

BUFFALO 2
Whitehead Metal Products Company, Inc.
254 Court Street
Tel. Cleveland 1475

CAMBRIDGE 39, MASS.
Whitehead Metal Products Company, Inc.
281 Albany Street
Tel. Trowbridge 6-4680

CHICAGO 23
Steel Sales Corporation
3348 South Pulaski Road
Tel. Bishop 7700

CINCINNATI 14
Williams and Company, Inc.
1921 Dunlap Street
Tel. Cherry 4700

CLEVELAND 14
Williams and Company, Inc.
3700 Perkins Avenue
Tel. Express 7000

COLUMBUS 15, OHIO
Williams and Company, Inc.
31 North Grant Avenue
Tel. Main 3291

DALLAS 9
Metal Goods Corporation
6211 Cedar Springs Road
Tel. Dixon 4-3925

DENVER 2
Metal Goods Corporation
817 Seventeenth Street
Tel. Main 9030

DETROIT 10
Steel Sales Corporation
5151 Wesson Avenue
Tel. Tyler 6-3000

HOUSTON 3
Metal Goods Corporation
711 Milby Street
Tel. Beacon 3-8881

INDIANAPOLIS 2
Steel Sales Corporation
1916 North Meridian Street
Tel. Talbot 8-1506

KANSAS CITY 2, MO.
Steel Sales Corporation
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Adjusts Tension Automatically. To hold proper speed relationship at all times between the stand motors, ohmic-drop compensation is provided by the G-E amplidyne. This electric "brain" automatically adjusts strip tension during acceleration and deceleration, thereby preventing strip breakage, possible damage to the mill rolls, and added scrap. The mill gets "on gage" faster, stays "on gage" longer.

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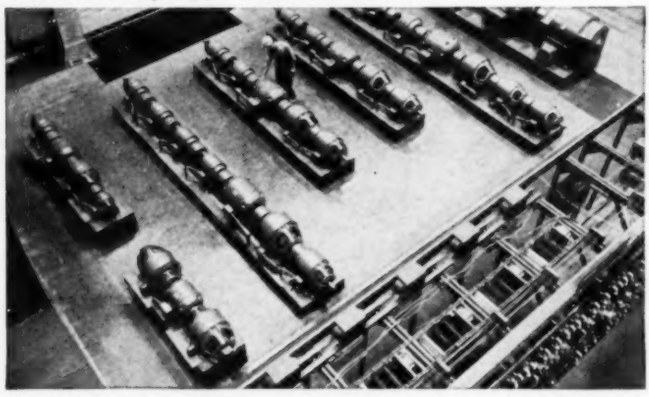
This individual-generator drive and its components, installed as a unit, is another example of General Electric's wide experience in engineering higher-speed, more accurately controlled steel mill drives. Whatever *your* drive problems, a G-E steel mill specialist will gladly discuss them with you and your own technical personnel. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*



With G-E amplidynes, shown above, the new mill can be accelerated from a 300-fpm threading speed to over 4500 fpm or decelerated from 6200 fpm to a dead stop—in only 6 seconds!

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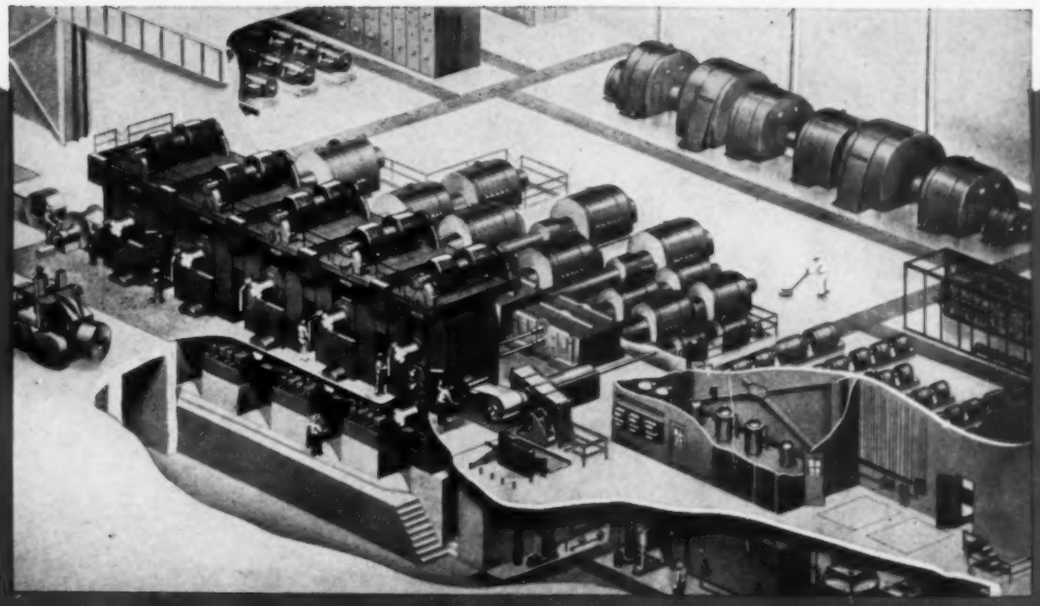
659-53



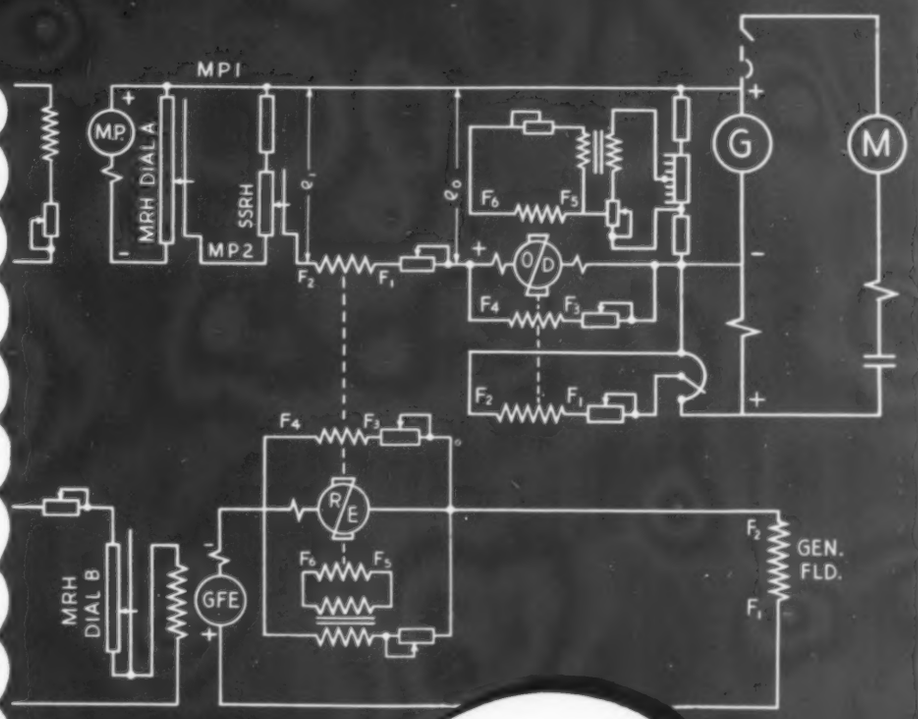
Complete electric equipment supplied by G-E for this 42-inch, 5-stand tandem cold-strip mill includes main driving motors (center), main m-g sets (rear), screw-down m-g set and 440-volt power distribution (left background), auxiliary m-g set and main control board (right center).

Here is how individual-generator control works on a single mill stand

In the control circuit shown on the right, the mill master rheostat determines the voltage on the master voltage-control bus MP1 and MP2, which is the standard by which the voltage on every generator is controlled. By raising or lowering the voltage on this bus, the voltages of all the generators may be raised or lowered proportionately. The mill master rheostat also controls the excitation on the generator-field exciter GFE which supplies all stand generators. In this way, regulating exciters RE on each stand can operate at low voltage levels ideal for fast regulator action.

Individual voltage adjustment on each generator is determined by the stand master rheostat. Each stand-motor speed can also be controlled by adjustment of its shunt-field current.

The ohmic-drop exciter OD receives its excitation from the voltage drop across the generator commutating field, and its output voltage may be made equal to (or any fixed percentage of) the motor-armature-circuit IR drop. The voltage of this amplidyne is automatically subtracted from the generator terminal voltage. Each stand regulator, through its regulating exciter RE, then acts to hold essentially motor cemf which is directly proportional to motor speed.



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Book Reviews

▲ With the progress in the development of industrial equipment, more and more problems are encountered in the forming and fabricating of parts of intricate design. The use of stainless steels in many industries is growing rapidly. A new book, "Forming of Austenitic Chromium-Nickel Stainless Steels," was compiled to give fabricators of metal equipment a better understanding of the exceptional adaptability of stainless steels to all modern processes of forming. This book presents a detailed description of the modern forming procedures as applied to chromium-nickel stainless steels and as practiced in the lubrication plants of the United States. Bending and straight flanging; forming of curved sections and tubing; deep drawing; die forming; forming of contoured-flanged parts, and forming by miscellaneous methods are some of the methods discussed in the book.

The unexpected demand for the book has exhausted the initial printing, and a second printing will be off the press about May 1, 1948. The book will be available only through International Nickel and copies of the second printing, as long as they are available, may be reserved in the United States by mailing checks of $4.00 for each copy to The International Nickel Company, Inc., 67 Wall Street, New York 5, New York, and in Canada by addressing The International Nickel Company of Canada, Limited, 25 King Street West, Toronto 1, Ontario.

▲ "An Introduction to the Physics of Metals and Alloys" by Walter Boas, formerly senior lecturer in physical metallurgy, University of Melbourne, Australia has just become available. This volume is based on a series of lectures in physical metallurgy and is written essentially for metallurgists and chemists. The main principle of the book is that the properties and the arrangement of the crystals determine the properties of polycrystalline aggregates. The book itself is divided into three sections. Part A takes up the principles of x-ray analysis, a field in which x-ray diffraction has been applied to determine the crystal structures of metals and alloys and the arrangement of the crystals in a polycrystalline aggregate. Part B describes and explains in terms of the properties of the atoms, the physical properties of metal crystals (including the plastic properties). In the light of this explanation the author discusses the properties of polycrystalline aggregates. The changes in the properties of metals produced by alloying and heat treatment form the subject of Part C. Publishers are John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, New York. Price $3.50, cloth, 193 pp.

▲ The fifth edition of the American Standard Specification for Dry Cells and Batteries, approved by the American Standards Association on August 6, 1947, is now available as Circular C466 of the National Bureau of Standards. The new specification, to be known as American Standard C18-1947, covers the first-grade product of manufacturers and includes all the types of batteries commonly used by the public. Its technical requirements have also been incorporated into a revision of Federal Specification W-B-101.

Publication of the 1947 edition of the standard marks another step in a project begun during the first World War and continued since that time with the cooperation of manufacturers and large industrial users of dry cells. This work has been accomplished through a sectional committee of the American Standards Association under the sponsorship of the National Bureau of Standards.

Advances in the dry-cell industry since the last previous specification of this type was issued in 1941 are incorporated in the fifth edition. For example, the small sizes of dry cells, including flat or miniature cells, receive more emphasis. Also included are specifications for radio battery packs combining low voltage for the A circuit and a higher voltage battery for the B circuit, a more complete standardization for hearing aid batteries, and standardized socket connections for radio A, B, and C batteries. In addition, there have been increases in the requirements of some of the old, established tests.

Circular 466 may be obtained at a cost of 10 cents from the Superintendent of Documents, Washington 25, D. C., or from the American Standards Association, 70 East 45th Street, New York, New York.

INDEX TO ADVERTISERS

A

Aetna Standard Engineering Company 1
Alliance Machine Company 25
Aluminum Company of America 23
American Air Filter Company, Inc. 161
American Brakeblok Division, American Brake Shoe Company 180
American Chemical Paint Company 146
Automatic Transportation Company 22

B

Babcock & Wilcox Company, The 5
Bailey Meter Company 4
Bantam Bearings Division of The Torrington Company 196
Bedford Foundry and Machine Company 144
Blaw-Knox Division, Blaw-Knox Company 152
Bloom Engineering Company 158
Bonnot Company 27
Buffalo Forge Company 151
Bussmann Manufacturing Company 138-139

C

Clark Controller Company 26
Cleveland Crane and Engineering Company 30
Cleveland Worm and Gear Company, The ..... Cover 3
Crane Company 176
Crouse-Hinds Company 137
Cunningham Company, M. E. 148
Cutler-Hammer, Inc. ..... Cover 2

D

De Laval Steam Turbine Company 172
Dixon Crucible Company, Joseph 150
Documentation & Licenses, Paris, France 34
Dollinger Corporation 33
Dowell, Inc. 163
Downtown Company 144
Dravo Corporation 158
Drever Company, The 34

E

Eastern Pipe Maintenance Company 183
Electric Controller and Manufacturing Company 9
Electric Service Manufacturing Company 32
Electric Storage Battery Company 155

F

Falcon Bronze Company 181
Farrel-Birmingham Company, Inc. 24
Flinn & Dreffein Engineering Company 34
Fluor Corporation, Ltd., The 184
Furnace Engineers, Inc. 183

G

General Electric Company ..... Cover 4, 28, 29, 188, 189

H

Hallden Machine Company, The 34
Hays Corporation, The 156
Hauck Manufacturing Company 179

I

International Nickel Company 187
I-T-E Circuit Breaker Company 159

J

Johns-Manville Corporation 8

K

Kling Brothers Engineering Works 173

L

Leeds and Northrup Company 14
Lewis Foundry and Machine Division, Blaw-Knox Company 157
Lincoln Engineering Company 178
Linde Air Products Company 165
Link-Belt Company 143
Lintern Corporation, The 175

M

McKay Machine Company, The 34
Mesta Machine Company ..... Cover 1
John Miles & Partner (London, Ltd.) 34
Morgan Construction Company 153
Morgan Engineering Company 140
Murray Manufacturing Company, D. J. 148

N

National Carbon Company, Inc. 170
National Roll & Foundry Company 2
New York and New Jersey Lubricant Company 191

O

Okonite Company, The 167

P

Pannier Corporation, The 160
Peerless Pump Division, Food Machinery Corporation 162
Pennsylvania Transformer Company 11
Pittsburgh Lectromelt Furnace Corporation 36
Pittsburgh Pipe Cleaner Company 177
Pittsburgh Rolls Division, Blaw-Knox Company 15
Poole Foundry and Machine Company 20
Post-Glover Electric Company 190
Pyle-National Company 174

R

Rockbestos Products Corporation 145
Rust Furnace Company 7

S

Salem Engineering Company 16
Smeeth-Harwood Company 179
Speer Carbon Company 10

T

Texas Company, The 3
Timken Roller Bearing Company 147
Torrington Manufacturing Company, The 13

U

Union Carbide & Carbon Corporation 165, 170
Union Steel Castings Division, Blaw-Knox Company 149
United Engineering and Foundry Company 19

W

Wagner Electric Corporation 6
Ware Fuse Corporation 181
Wean Engineering Company, Inc., The 34
Wean Engineering Company of Canada, Limited, The 34
Wean Equipment Corporation 34
Whitcomb Locomotive Company, The 12
Wilson Engineering Company, Inc., Lee 21

Y

Youngstown Alloy Casting Corporation 169
Youngstown Welding and Engineering Company 154

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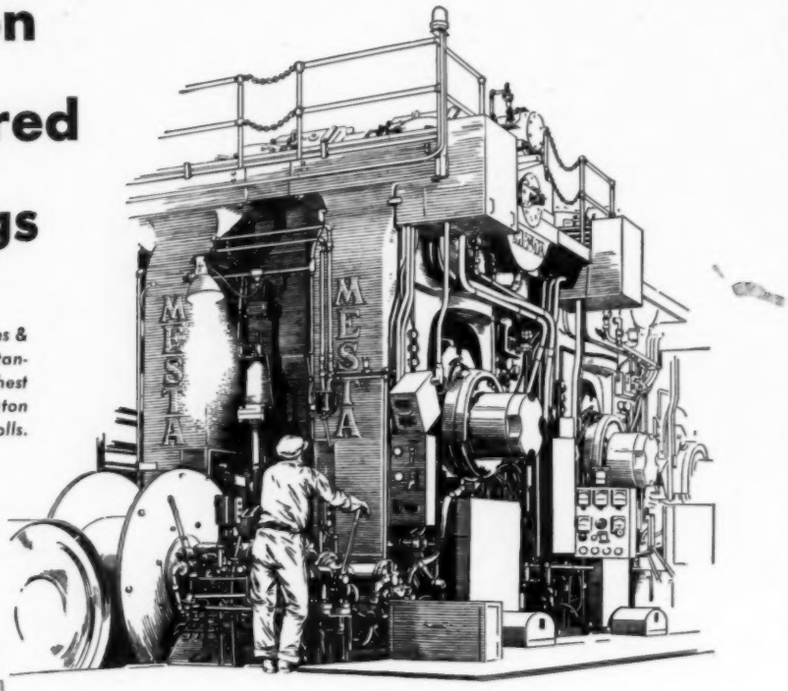

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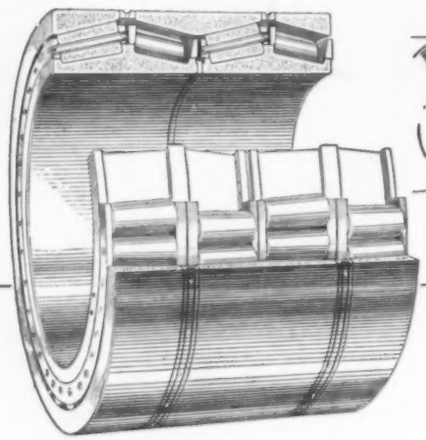

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